MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

MANAGEMENT WEEK, OCTOBER 16-21

The operating problems of our complex industrial organization will be discussed during Management Week before joint sessions of the Taylor Society, the Society of Industrial Engineers and the Management Division of the A.S.M.E., including the local sections of all three societies.

OCTOBER · 1922

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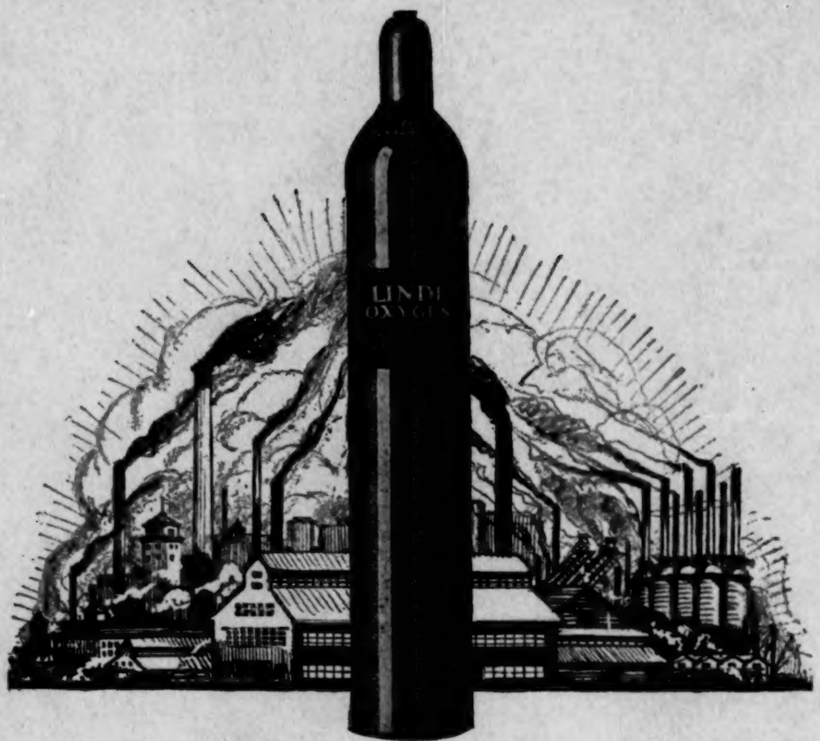

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Contributors and Contributions

The Hydraulic Turbine in Evolution

H. Birchard Taylor

Important questions arising from the rapid evolution of the hydraulic turbine and precautions to be observed are discussed by H. Birchard Taylor and Lewis F. Moody. Mr. Taylor was graduated from the University of Pennsylvania in 1905, where he had taken a special course in mechanical and civil engineering. He entered the hydraulic department of the I. P. Morris Co. in 1905 and in 1915 was appointed assistant to the president of The William Cramp & Sons Ship & Engine Building Co., of which the I. P. Morris Co. was made a department. In 1917 he was made vice-president of the Cramp Company and relinquished his work as hydraulic engineer in order to take over executive duties. He has always retained an active interest in the technical side of hydraulic engineering, however, and is the author of many contributions to the technical press and the originator of a number of inventions.

Lewis F. Moody received his B.S. from the University of Pennsylvania in 1901 and his M.S. the following year. For the next two years he was an instructor in mechanical engineering at the University and then became an engineer in the I. P. Morris Department of The William Cramp & Sons Ship & Engine Building Company. From 1908 to 1916 he was assistant professor of mechanical engineering and then professor of hydraulic engineering at Rensselaer Polytechnic Institute. He then returned to the Cramp Company as consulting engineer and since 1918 has been assistant to the vice-president.

Lewis F. Moody

Forces in Rotary Motors

When Karl White received his degree of B.S. in mechanical engineering from the University of Kansas in 1921, his thesis was the paper which appears in this issue under the title of Forces in Rotary Motors. Mr. White's college course was interrupted by the war. He left school to work for the Thomas Morse Aircraft Co., at Ithaca, and for the Curtiss Engineering Corporation, at Garden City, L. I. His spare time while in college was devoted to the construction of a rotary-motored biplane designed by L. M. Allison, a member of the A.S.M.E. Since his graduation he has been employed in the airplane-engineering department of the Aeromarine Plane and Motor Co., of Keyport, N. J.

High-Pressure Steam-Heating Lines

Edgar Buckingham, who contributes a paper on High-Pressure Steam-Heating Lines, is a graduate of Harvard, class of 1887. He was a graduate student at Strasbourg and later, in 1893, received his Ph.D. from Leipzig. Mr. Buckingham was an assistant in the physics departments of Harvard, Strasbourg, and Bryn Mawr, and in 1898 became associate professor of physics and physical chemistry at Bryn Mawr. In 1901 he went to the department of physics at the University of Wisconsin and the following year became assistant physicist for the Bureau of Soils, U. S. Department of Agriculture. Since 1906 he has been in the Bureau of Standards. He has been a special lecturer at the graduate school of the U. S. Naval Academy, and for a year was associate scientific attaché at the U. S. Embassy at Rome.

The Degasification of Boiler Feedwater

A discussion of Fundamental Laws governing the separation of dissolved gases from water by air-tension control appears in this issue, contributed by J. R. McDermet. Mr. McDermet has received three degrees from the University of Illinois—B.S. in 1912; M.S. in 1914; and E.E. in 1916. The University of Pittsburgh conferred the degree of M.E. in 1916. Mr. McDermet did research work at the Mellon Institute in boiler-feedwater purification, ventilation, petroleum-refinery development and methods of acetylene generation. Since 1918 he has been research engineer with the Elliott Company at Jeannette, Pa., where he has worked primarily on the problem of deäeration of boiler feedwater.

An Investigation of the Herschel Type of Weir

This is an abridgment of the paper that was awarded the A.S.M.E. Student Prize for 1921. It discusses the results of tests made to determine the effect of certain modifications in construction on the action of the new type of weir devised by Clemens Herschel and described in Mechanical Engineering of February, 1920. Richard H. Morris received his A.B. and B.S. from the University of California in 1920, and since then has been a student at M.I.T. and in the employ of the Worthington Pump & Machinery Corporation. Albert J. R. Houston received his B.S. in mechanics from the University of California in 1920 and is a graduate student at M.I.T.

Fuel Problems of the Pacific Coast

Four members of the A.S.M.E. have contributed a group of papers which discuss the railway and marine fuel problems of the Pacific Coast, as well as those of the future fuel supply of California. C. H. Delany is connected with the Pacific Gas & Electric Co. in San Francisco; David Dorward, Jr., is a consulting engineer of San Francisco; F. H. Sibley is professor of mechanical engineering at the University of Nevada, Reno, Nev. and J. C. Martin, Jr., is a mechanical engineer in the employ of J. C. Martin & Co., San Francisco.

MANAGEMENT WEEK
October 16-21

As we go to press, twenty-two Local Sections of the A.S.M.E. have announced their program for Management Week. For details see the A.S.M.E. News.

MECHANICAL ENGINEERING

Volume 44 October, 1921 No. 10

The Hydraulic Turbine in Evolution

New Problems Created by Turbine Evolution—Analysis of Flow in a High-Speed Turbine—Correlation of the Marine Propeller with the Hydraulic Turbine

By H. BIRCHARD TAYLOR[1] AND LEWIS F. MOODY,[2] PHILADELPHIA, PA.

If we view the present stage of development of the hydraulic turbine against its historical background, there are many indications that we are in the midst of a transition period. There was a similar time of transition in 1890 to 1900 when the turbine was being developed to meet the requirements of electrical generation, and as pointed out in the paper by one of the authors presented last year,[3] one phase of that transition period was an increase in complexity marked particularly by the adoption of multi-runner units. Another transition occurred about 1911 to 1912, marked by a return to greater simplicity and the readoption of the single-runner vertical machine.

For almost ten years the hydraulic turbine remained nearly stationary in its development, accepted practice settled upon a nearly standardized design, and there seemed to be room for little further improvement in efficiency, speed, or mechanical design. Nevertheless within the last two or three years a surprising number of new lines of progress have been opened up and the turbine, and with it other features of water-power engineering, is again in a healthy state of change.

Notable progress has been accomplished by a number of engineers in the extension of the range of available speeds, so that extremely high specific speeds are now obtainable with satisfactory efficiency. The authors have for a number of years been devoting particular attention to this high-speed field and the possibilities which the extension of the field has opened up. This paper will describe some of the lines of development which have been followed and some of the problems involved in applying the new turbine forms which have been developed.

Problems Created by Turbine Evolution

As an indication of what has been accomplished, Figs. 1 and 2 show in preliminary form the design of an installation now under construction involving a turbine runner which is within a few inches of the same diameter as that installed at the great Cedars Rapids plant on the St. Lawrence containing the largest runners in existence today. The turbine shown in these figures, however, is of very nearly twice the specific speed which was available at the time the Cedars turbines were designed. It should also be recalled that the specific speed adopted in the Cedars plant represented a notable step in advance at the time that installation was completed, namely, 1914. This ability to use double the speed which was available eight years ago represents a material saving in the cost of the turbines, generators and power-house structure.

Not only is the weight and cost of the generator reduced in even greater ratio than the saving in the turbine, but the reduction in weight of parts to be handled by the power-house cranes reduces the weight of the station superstructure, and it is also possible in installations now carried out to effect considerable savings in the amount of excavation necessary for the power-house substructure, to mention only a few of the principal factors affected by the recent progress. The turbine of Figs. 1 and 2 is of the diagonal-propeller type. As shown in Fig. 2, instead of employing the usual continuous "speed ring" at entrance to the guide vanes, the design involves the use of separate stay vanes. In addition to the stay vanes at entrance, a second series of stay vanes are used in the spreading draft tube, as shown in Fig. 1. Fig. 3 shows a 16-in. turbine of the same type tested in the I. P. Morris Laboratory.

Although great progress has been made in the attaining of higher speeds, another question remains to be investigated, and that is the extension of the application of these high-speed turbines to higher heads.

For a long time it was common practice to select the type of turbine for any installation by taking the value of specific speed from a so-called "experience curve" which was plotted between the variables: head and specific speed. Thus it was assumed that for any given head available for a projected plant, the specific speed adopted should not be higher than the limit shown by such a curve. But the specific speed permissible for any installation is not a function solely of the head on the plant but it is also dependent upon the elevation of the turbine runner with respect to the surface of tailwater. About all that can be said for the "experience curve," is that by its use, turbines can be selected for any given installation which will be capable of being set at some arbitrary height above the tailwater consistent with customary practice. This method, however, of selecting specific speeds for any projected plant is not of much value even as a rough approximation and should not be relied upon, since it neglects so many factors of importance, among them being the possibilities opened up by the latest advances in this field of engineering. For example, there are probably many plants where the elevation of the runner above tailwater has been placed at an arbitrary distance, where it would have been possible by lowering this elevation to permit the adoption of considerably higher speeds and at the same time to reduce the risk of corrosion and vibration.

Referring, for instance, to the type of turbine shown in Figs. 1 to 3, it may be pointed out that there is no strong necessity when this turbine is installed to place the runner above high tailwater level. The probability of emergencies arising which would require the shutdown of the unit for examination or repair is very slight in large modern installations of the high class of design and workmanship now available. It is therefore not likely that it will be necessary to gain access to the runner during times of abnormal height of tailwater. Moreover, in the new forms of high-speed turbines when built in the large sizes of units now being adopted, it is not necessary to provide a manhole for entrance to the draft tube below the runner, since this space is readily accessible through the wide openings between the runner blades. It is therefore possible in many plants to place the runners close to the normal tailwater elevation without likelihood of any serious inconvenience.

As mentioned in the paper of last year, moreover, a further departure from customary practice has been proposed by one of the writers, involving the placing of the runner below tailwater. This suppression of the runner may be accomplished either by providing tail-race gates to permit access to the runner, or by adopting the inverted arrangement of the turbine. As a matter of interest and to show some of the possibilities of this plan, Fig. 4 is given, representing a proposed arrangement of the Taylor inverted turbine. One of these turbines was tested with one runner in both the inverted and conventional positions in order to satisfy the skeptical that the performances would be identical—as they were.

[1] Vice-President, The Wm. Cramp & Sons Ship and Engine Building Co. Mem. Am.Soc.M.E.

[2] Assistant to Vice-President, The Wm. Cramp & Sons Ship & Engine Building Co. Mem. Am.Soc.M.E.

[3] The Present Trend of Turbine Development, by Lewis F. Moody, Mechanical Engineering, vol. 43, no. 4, April, 1921, p. 235.

Abridgment of a paper presented at a meeting of the Philadelphia Section of The American Society of Mechanical Engineers, Philadelphia, March 21, 1922.

Analysis of Flow in a High-Speed Turbine

In order that the questions raised by the use of the new turbine types under an increasing range of heads may be considered more in detail, the following method of analyzing the flow through a high-speed turbine is given.

In some aspects the high-speed turbine has approached the marine propeller, but while some forms of high-speed turbines resemble a marine propeller rather strikingly in appearance, there are essential differences in action. In the marine propeller the water approaches the propeller in directions parallel to the axis of rotation; in the high-speed turbine of Fig. 3, the water enters the turbine with radial inward components of velocity directed toward the axis and also with an increasing tangential or whirl component about the axis. The radial component is turned into a diagonal direction, and in this

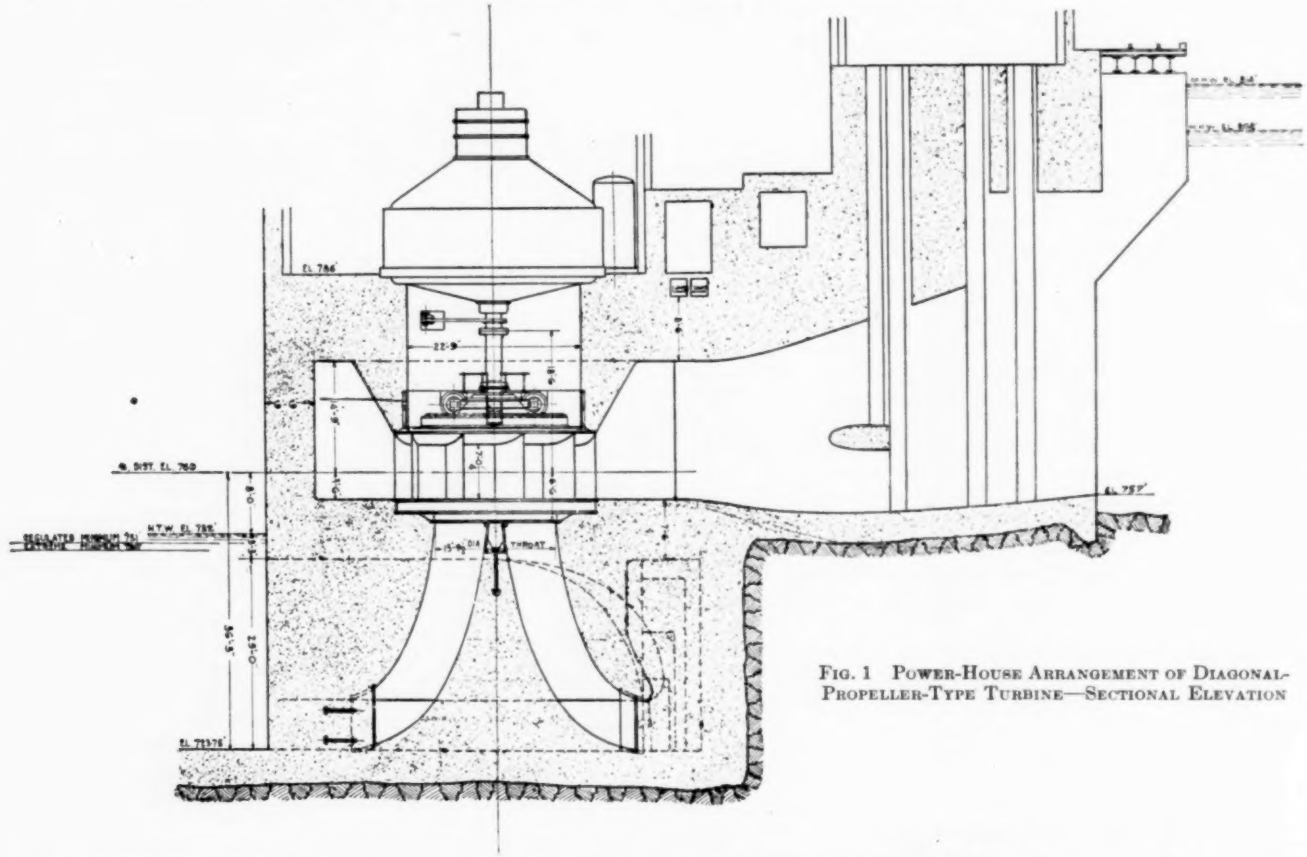

Fig. 1 Power-House Arrangement of Diagonal-Propeller-Type Turbine—Sectional Elevation

type this turning then proceeds continuously as the flow passes through the runner until the discharge becomes axial and finally outward, away from the axis. The flow as it progresses through the turbine can be thought of as containing three kinds of rotation, or whirl, which take place simultaneously about three different axes.

In the complete form of the turbine, such as shown in Figs. 1 and 2, the water enters the turbine through a volute casing in which it takes up a motion of rotation about the turbine axis, which is increased as the water passes through the stationary guide vanes and approaches the axis. This rotation may be called the "primary whirl." As shown in the paper of last year, this whirl, while partially abstracted by the runner, still persists in reduced degree in the draft tube. It has apparently been the effort of some designers to adapt their runners to remove all whirl from the water and to discharge the water without rotation, and many of the draft tubes now used or proposed are adapted to handle only non-whirling flow; and many of such draft tubes—especially the formerly prevalent elbow type—are very defective in operation with any kind of flow. It was demonstrated in the previous paper, however, that when a runner discharges into a draft tube which is capable of regaining the energy of whirl, the most efficient condition of operation of the runner is attained when the water is discharged in an oblique direction, containing a definite tangential velocity component about the axis. It therefore follows that a high-speed runner when equipped with a whirl-regaining draft tube will operate most efficiently at a higher speed and that its efficiency will then be higher than is possible with other types of draft tube. Indeed, if runners of the speeds now being used are installed with improperly designed draft tubes, serious loss of power and efficiency may be looked for, as well as vibration and unsteady operation.

In analyzing the action of this "primary whirl" which the water possesses in some degree throughout its passage through the turbine, the law of constancy of moment of momentum may be applied to all spaces in which the water can whirl freely without the influence of directing vanes or obstructions. In accordance with this law, the tangential velocity in such spaces will vary inversely as the radial distance from the axis. We may start to apply this principle to the flow in the volute casing of the turbine and may form the walls of the volute to conform with such a mode of flow.

In designing the volute casing in this manner, the cross-sectional area of the volute passage will decrease in passing around the circumference of the turbine at a rate sufficient not only to provide for the decrease in quantity of flow remaining in the volute at each section, but also to provide for a continually increasing velocity. When applying this law to the velocity at any section, it may be taken as inversely proportional to the radius to the center of gravity of the section. In a casing designed by this method the walls will conform to the natural path of the water, and there is no reason to expect any greater loss of head in such a casing than that corresponding to the friction loss in an equivalent length of straight pipe.

After the water leaves the guide vanes, it passes inward toward the axis, its velocity continuing to increase in inverse proportion to the radius; and since more and more of its pressure head is converted into velocity head, its pressure decreases. If the freely whirling water is permitted to approach the axis closely, low pressures will occur, appreciably lower than atmospheric in many cases. Thus, we shall have even on the entrance side of the runner pressures of low absolute value, sometimes but little above the pressure in the draft tube; and this is evidenced in actual operation in some designs by the drawing of air through stuffing boxes into the transition space in advance of the runner.

Since points of low pressure are conducive to cavitation, or the formation of voids in the water stream, with tendencies toward

eddy formation, the formation of air pockets, and danger of corrosion and vibration, it is, of course, desirable to avoid any such low-pressure regions. An undue reduction in pressure in advance of the runner can be avoided by the admission of the water to the runner before it has approached too closely to the axis, the further reduction in pressure which the water must experience on its way to the draft tube then taking place within the runner during the process of transferring energy from the water to the runner. A reduction in pressure in advance of the runner is aggravated when the turbine is operating at part gate if it is equipped with the usual wicket gates, since at part gate the water leaves the guide vanes with increased velocity in a more tangential direction and with lower pressure; and the pressure starting at a lower value near the guide vanes drops more rapidly toward the axis. It may easily happen, particularly at part gate, that pressures may exist in the inner portion of the entrance space to the runner which are equal to, or even less than, the pressure in the draft tube. The new diagonal form in runner blade is adapted to prevent an undue pressure reduction of advance of the runner blades by providing a considerable diameter for the inflow edge of the blade where it joins the runner hub.

Another consideration which leads to the adoption of a diagonal-flow runner in preference to the purely axial-flow type is that as the stream elements at the upper portion of the guide vanes approach the axis the velocity of the water increases in inverse proportion to the radius. The velocity of the entrance edges of the runner blades,

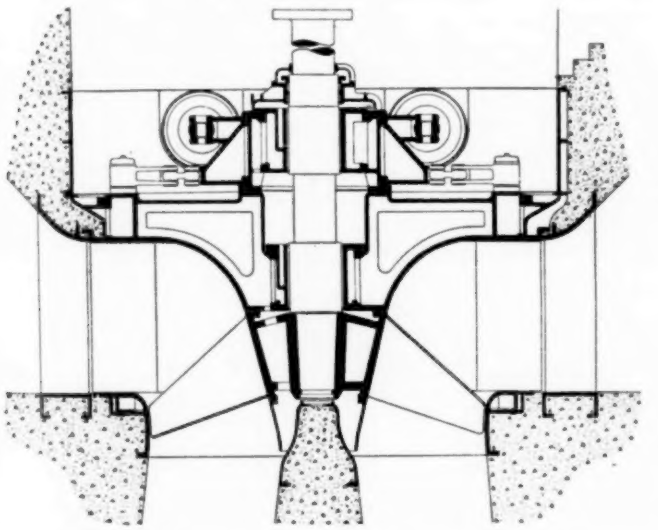

Fig. 2 Sectional Elevation of Diagonal-Propeller-Type Turbine

however, decreases in direct proportion to the radius, so that if the flow is carried too near the axis it may readily occur that the water will be traveling faster than the runner, requiring a backward angle of the runner blade and leading to complicated curvature and inefficient action. There is no necessity for the close approach to the axis, and by carrying the runner blades diagonally across the entrance passage an efficient runner has been produced and one having great mechanical strength due to the length and form of the blade section where it joins the runner hub.

Since the primary whirl persists, although in reduced amount, at discharge from the runner, it is desirable, when structurally feasible, to provide in the draft tube a central core continuous with the runner hub. The provision of this core avoids the tendency toward the formation of a central cavity within the flowing stream with the resulting production of eddies, turbulence, and unsteady flow.

The second kind of whirl in the turbine occurs in meridian planes, that is, planes containing the turbine axis, and constitutes a rotation about axes perpendicular to these meridian planes. This rotation sets up an increase in pressure toward the upper and inner surface of the entrance space to the runner, and an increase in velocity and decrease in pressure at the lower distributor plate and runner tips. This "secondary" whirl therefore reduces the velocity of the stream elements leaving the upper part of the guide vanes and correspondingly reduces the velocity attained at entrance to the runner by these elements which enter the runner nearest to the axis; the stream elements leaving the lower end of the guide vanes are increased in velocity by this secondary whirl, but as these elements move inward toward the turbine axis only a small distance, their velocity is not further increased by any great amount.

The primary and secondary whirls, therefore, tend to some extent to neutralize each other in their effects of causing unequal distribution of the velocities and pressures in different portions of the stream. After turning the water from an inward direction to the axial, it then becomes desirable to turn the water outward and to conduct it away from the axis as an excellent means for regaining as much as possible of the energy of whirl with which it leaves the runner, while at the same time regaining the energy corresponding to the meridian component of velocity. The deflections from radial

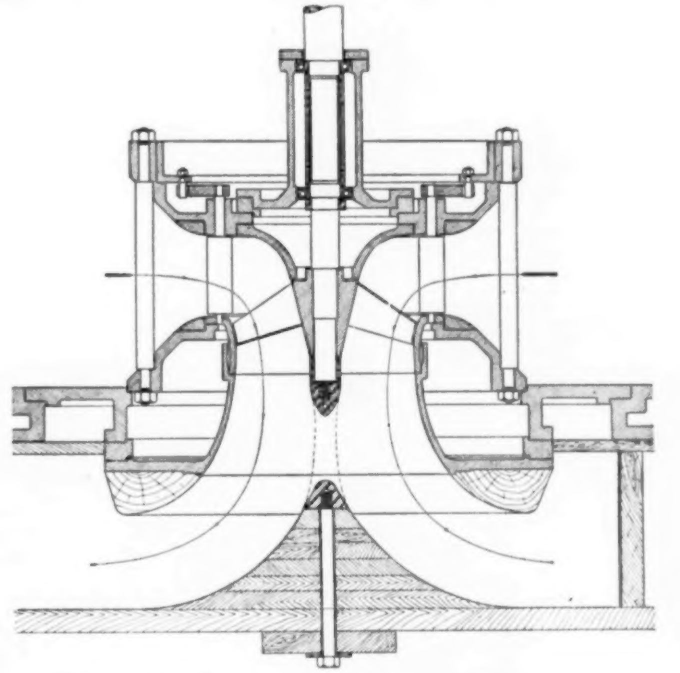

Fig. 3 16-in. Diagonal-Propeller-Type Turbine

inward flow to axial flow and from axial to radial outward flow can very well be made continuous in a turbine designed to occupy small space in an axial direction. Fig. 3 shows such a design in which the secondary whirl is maintained and gradually reduced in magnitude as the flow attains the outward direction, without any abrupt changes in curvature of path.

The third kind of whirl is a local whirl having a fixed relation to each blade of the runner and carried around with the blade, the axis of this whirl being transverse to the general direction of flow and lying approximately in a revolving meridian plane. Consider the flow behind a blade, Fig. 5. The water adjacent to the rear surface of a blade will follow a curved path so that it may change in direction to correspond with the deflection produced by the blades and thus develop torque on the runner. The curvature of the path of successive stream elements will decrease at points receding from the blade, and at some distance from the blade the curvature will disappear. The flow behind each blade therefore contains a whirling motion approximating in some degree to a rotation about an axis normal to the plane of the figure. This axis may be taken as the center of an arc coinciding with the rear surface of the blade. If we apply to this local whirl the laws of a free vortex and suppose the velocity relative to the blade to vary inversely as the radial distance from the axis of rotation, we will have a picture of the flow sufficiently close to what probably occurs behind a blade to furnish us some useful conclusions. Such a local vortex at each blade would result in a local reduction of pressure on the back surface of the blade, and it is shown in the complete paper that the probable amount of such local pressure reduction is approximately equal to—

$$h_p - h_{pb} = \int_{r_b}^{r} \frac{w_b^2 r_b^2 dr}{g r^3} = \frac{w_2^2}{2g}\left(1 - \frac{r_b^2}{r_c^2}\right)$$

where h_p is the pressure head at any point in the stream, h_{pb} and r_b are the pressure head and radius at the back surface of the blade, r_c a radius dropped perpendicularly upon the center line of the preceding blade, and w_2 the relative velocity at the rear surface of the blade. This represents the amount by which the local pressure on the surface of each blade falls below the average pressure at the top of the draft tube. The actual amount of this reduction will vary greatly with the form, length, and spacing of the blades in any particular runner.

As any tendency of the water to leave the vane surface is believed to be conducive to cavitation, with resulting risk of corrosion and vibration, it is considered highly important to provide enough margin of pressure in the draft tube below the runner to take care of this local pressure drop, so that an adequate intensity of absolute pressure will still remain at the vane surface. This consideration requires that the runner be placed at an elevation above tailwater not exceeding a value consistent with the Bernoulli formula applied to the draft tube, with due allowance for the above local pressure drop.

One useful method of determining the allowance for the local pressure reduction is by referring to marine-propeller practice. Conservative practice in marine-propeller design dictates that the tip speed of the propeller should be kept below a fairly definite limit based on experience with actual propellers which have developed serious vibration or corrosion. If we express the local pressure drop in terms of velocity head corresponding to tip speed rather than to relative velocity, these velocities being not greatly different in propellers and high-speed runners, and if we assume that vibration and corrosion are due to cavitation produced when the local pressure at some point in the propeller or runner has been reduced to an extent sufficient to overcome the static pressure of the atmosphere and the depth of immersion of the top of the wheel, we can obtain an expression of the form—

$$\text{Local pressure drop} = (\text{a coefficient}) \times \frac{(\text{tip speed})^2}{2g}$$

in which the coefficient is determined by inserting in this formula the total static pressure at the top of a propeller and the corresponding tip speed which has been found to give safe protection against cavitation for ordinary forms of blades.

Although the allowance to be made in any given turbine installation depends on many factors, as already pointed out, the above will give a general idea of the magnitude of the effect of the local whirl or vortex at each blade.

One of the things to be avoided is an undue reduction in blade surface, particularly for turbines operating with inadequate margin of pressure in the draft tube. Insufficient blade area is not only conducive to cavitation at normal load, but gives rise to unsteady or unstable operation at part load. Evidently the driving torque on the runner is derived from the pressure difference between the face and back of blade, resolved into the tangential direction. If the angle of inclination of the blades is small with respect to the tangential direction and the blade area small, a high intensity of pressure increase is required on the blade face, and a high intensity of decrease on the back. A small number of narrow blades therefore magnifies the problem outlined above.

A comparison of the performance curves of a four-bladed, axial-type runner with those of a six-bladed diagonal runner shows that the axial runner has marked instability at small gates, while the curves of the diagonal runner are smooth and of normal form.

Reports have come to the authors of serious vibration in several high-speed installations. We may conclude from some of the considerations pointed out above that such vibration may be due to one of the following causes, or a combination of them: a defective

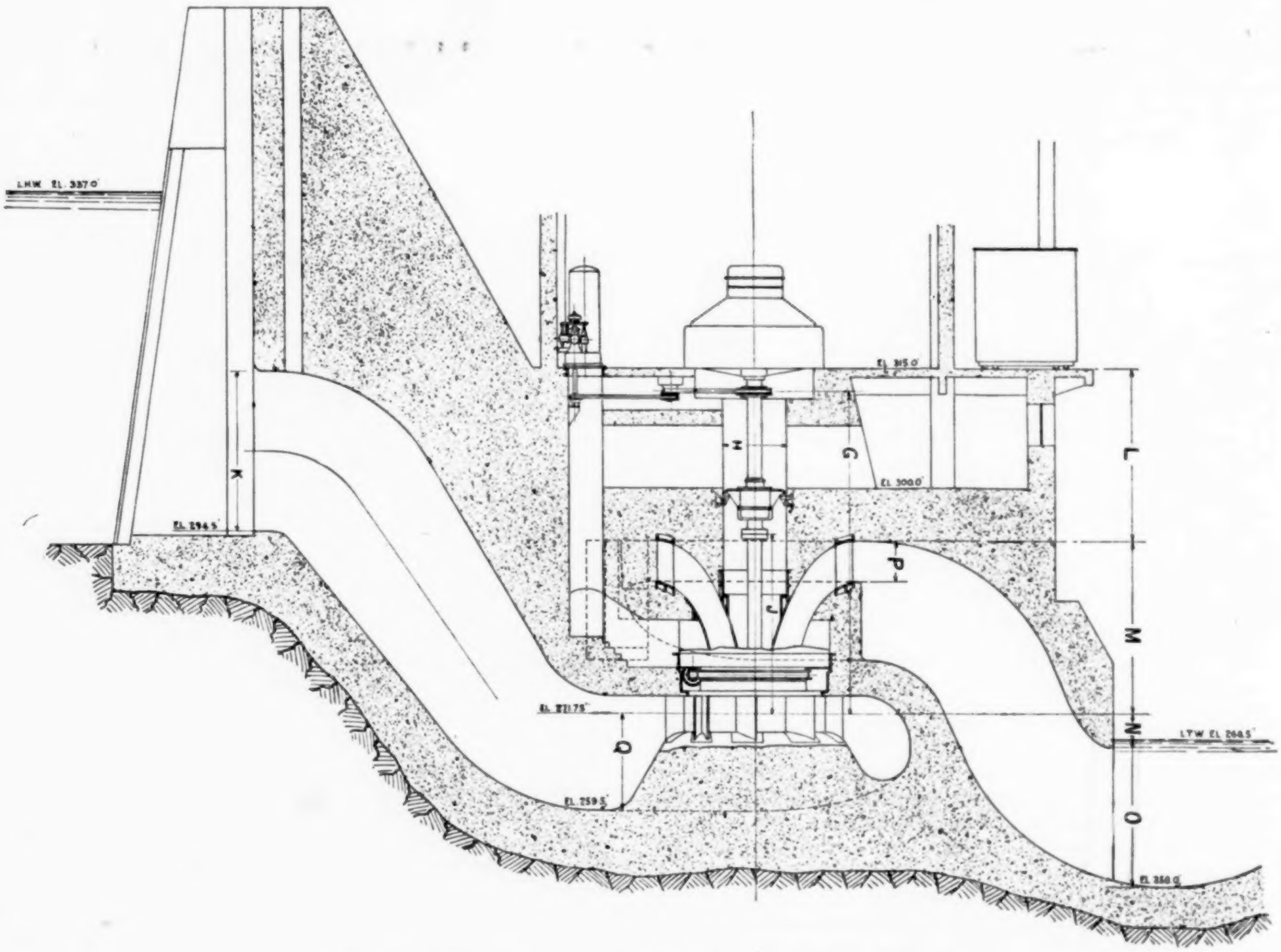

FIG. 4 PROPOSED ARRANGEMENT OF TAYLOR INVERTED TURBINE

form of draft tube, excessive draft head, local cavitation, or unstable flow in the runner.

The high specific speeds now available involve other limitations besides those already mentioned. If extreme values of specific speed are adopted, a sacrifice in part-gate efficiencies must be accepted; but if the speed selected is within moderate bounds, very satisfactory performance curves are available. Fig. 6 shows a comparison of performance curves of a number of runners, all of 16 in. throat diameter, tested in the I. P. Morris Laboratory. Curves *A* and *B* are for runners of the so-called "Francis" type, or the usual mixed-flow, high-speed type of recent popularity. The runner corresponding to curve *B* is a model of the 16-ft.-diameter runners at Cedars Rapids, a larger model of which (of about twice the size of this one) gave 90 per cent efficiency at Holyoke; so that all of the results in Fig. 6 can be considered equivalent to some four or five per cent increase in a larger model. Curve *C* shows the performance of a runner of slightly over 100 specific speed (foot-pound system used throughout), and the excellent part-gate results will be noted. This is a diagonal-propeller-type turbine with a six-bladed runner operating with a spreading draft tube. Curve *D* corresponds to a turbine of the same type but of considerably higher specific speed (144), and its performance is also excellent. Curves *E* and *F* are for the same runner as *D*, but overspeeded, giving specific speeds of 180 and 225, with poorer performance, particularly at part gate. Curve *G* is for a four-bladed axial-type runner, with very poor part-gate results.

As it is believed that there is a tendency in a narrow-bladed runner for an eddy to form behind each blade at part gate and sometimes even at normal gate, one of the authors has proposed the use of secondary blades close to the main blades but slightly in advance of them, for the purpose of directing the flow more efficiently along the back of the main blade, and by this means eliminating instability and vibration and improving the part-gate efficiency, etc. Fig. 7 shows a four-bladed axial-flow runner equipped with such secondary blades, the two blades being in contact in the position shown. The secondary blade is of diagonal-flow form. It was found by tests that the addition of the secondary blades or "intervanes" reduced

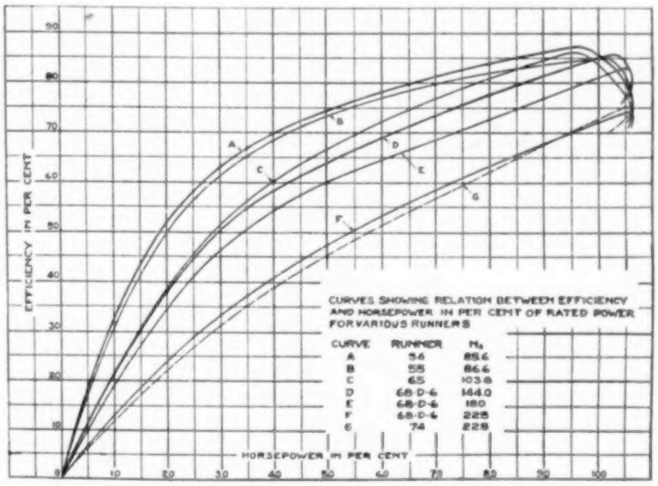

FIG. 6 COMPARATIVE PERFORMANCE CURVES OF 16-IN. TURBINES OF DIFFERENT SPECIFIC SPEEDS

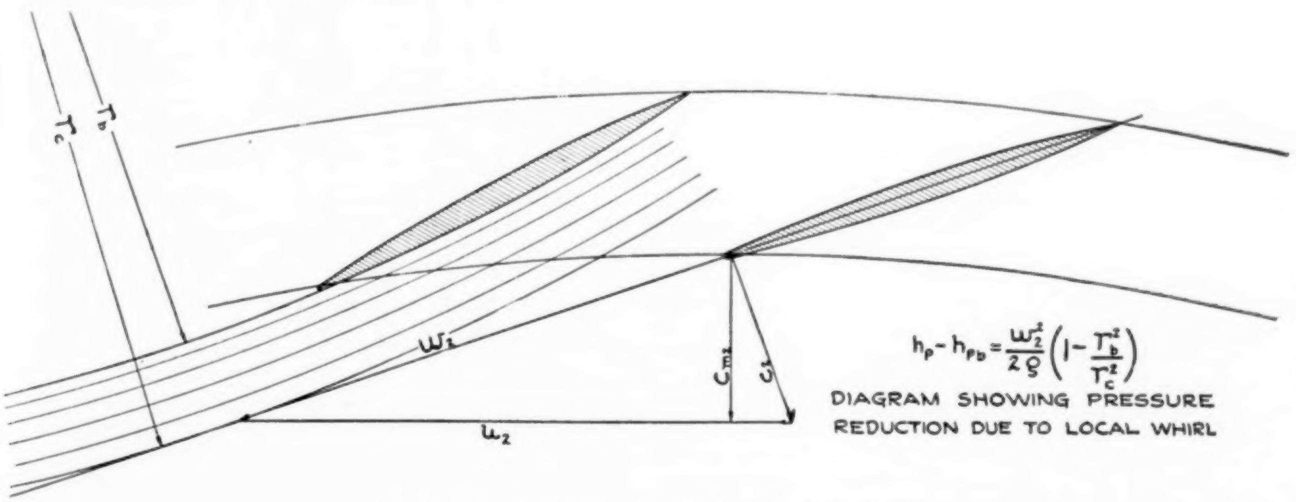

FIG. 5 DIAGRAM OF LOCAL VORTEX BEHIND RUNNER BLADE

the specific speed, but increased the efficiency by 8 per cent and that it prevented unstable flow and vibration and improved the part-gate efficiency. It was found that the best angular position of these blades was about 10 deg. in advance of their position of contact with the main blades. The field of usefulness of the idea has yet to be determined; it is merely presented here as a suggestion of interest.

In order that the reader may appreciate the magnitude of the problems involved in applying the new turbine forms to large modern developments, it may be mentioned that the turbine of Figs. 1 and 2 will develop 28,000 hp. under 56 ft. head at a speed of $138^1/_2$ r.p.m.; and that this requires a tip speed of the runner of nearly 80 miles per hour or $1^1/_3$ miles per minute, more than the speed of the Broadway Limited. For comparison, the peripheral speed of the 55,000-hp. runners of the Queenston-Chippawa Development, operating under 305 ft. head, is only 67 miles per hour, and the circumferences of the 37,500-hp. runners of the Niagara Falls Power Company (214 ft. head) move at a rate of less than "a mile a minute."

CORRELATION OF THE MARINE PROPELLER WITH THE TURBINE

We have already alluded to the similarity in general appearance of some of the new forms of high-speed turbine to the marine screw propeller, and we have applied to turbines some of the conclusions from marine practice. It has probably occurred to many that there must be similarities in action between the new turbines and propellers; and although we have pointed out above several essential differences in the action of these devices, it has seemed to the authors that it would be worth while to investigate the performance of the propeller in its relation to the action of the turbine, to see whether it would not throw some light on the future possibilities open to us in the direction of further increases in specific speed, and on the probable forms to be looked for in turbines capable of developing higher speeds. We think that the results of this investigation are worth presenting here.

One difference between the turbine and the propeller is that the latter works in open water and is not enclosed. This difficulty can be met without introducing the probability of serious error by supposing the flow through the propeller to take place within definite imaginary boundaries, surrounded by water which does not partake of the action (See Screw Propellers for Hydraulic and Aerial Pro-

pulsion, second edition, be Rear-Admiral Charles W. Dyson, Fig. 1-A). A second difference—and one of considerable importance—is that the water enters the propeller with a high relative velocity and although the propeller increases this velocity and discharges the water at a still higher velocity, the relative discharge velocity is only moderately in excess of the speed of advance of the propeller. This excess represents an absolute sternward velocity, the head corresponding to which is a loss of energy corresponding to the "outflow loss" in a turbine. If the propeller should be considered, however, as operating as a turbine or pump, the head due to the entire relative velocity of discharge would represent a loss, unless the necessary step

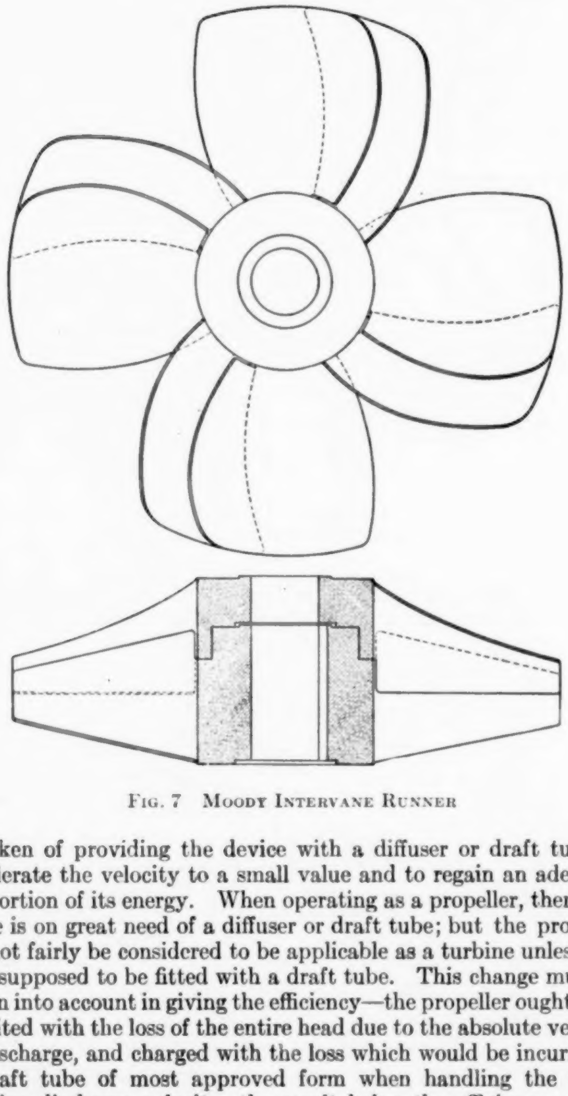

Fig. 7 Moody Intervane Runner

is taken of providing the device with a diffuser or draft tube to decelerate the velocity to a small value and to regain an adequate proportion of its energy. When operating as a propeller, therefore, there is on great need of a diffuser or draft tube; but the propeller cannot fairly be considered to be applicable as a turbine unless it is also supposed to be fitted with a draft tube. This change must be taken into account in giving the efficiency—the propeller ought to be credited with the loss of the entire head due to the absolute velocity of discharge, and charged with the loss which would be incurred in a draft tube of most approved form when handling the whole relative discharge velocity, the result being the efficiency of the equivalent turbine. If V is the speed of advance of the propeller through still water, c the absolute velocity of discharge, c_u its tangential component and c_m its axial or meridian component, the outflow loss of the propeller is—

$$\frac{c^2}{2g} = \frac{c_u^2 + c_m^2}{2g}$$

and that of the equivalent turbine is—

$$f\,\frac{(V + c_m)^2 + c_u^2}{2g}$$

in which f is the proportion of the velocity head lost in diffusion—which will here be taken as 20 per cent, corresponding to an ordinarily efficient draft tube.

The first quantity which it is necessary to calculate is the head, a quantity which does not appear in the ordinary propeller calculations. Defining the head as the energy per pound of water passing through the wheel, we can distinguish three values of head: the transmitted or equivalent head H_e, that is, the head corresponding to the mechanical horsepower transmitted by the propeller shaft, and from the wheel to the water, or in a turbine from the water to the wheel; the lost head, made up first of internal losses in the wheel due to surface friction of the blade surfaces, impact or eddies, which we shall include in the term L, and the outflow loss L_1, which we have already seen is equal to $c^2/2g$; and finally, the delivered head H_1, corresponding to the horsepower realized in the thrust of the screw acting through the distance per second equal to the speed of advance. Evidently—

$$H_e - L - L_1 = H_1 \text{ and } \frac{H_1}{H_e} = e_1$$

where e_1 = propeller efficiency.

It is shown in the complete paper that $H_1 = T/WA$, where T is the axial thrust, lb.; W the weight of water per cu. ft.; and A the disk area of the propeller $= \pi R^2$, where R is the blade-tip radius.

To visualize the relation of H_e, H_1 and lost head the diagram of Fig. 8 (a) is given, in which H_1 is shown as the portion of H_e remaining after deducting the losses L and L_1.

For completeness, we have shown in the same figure diagrams (b) and (c) representing the relation of heads in the propeller working as a pump and a turbine respectively. The only modification in changing from (a) to (b) is that instead of a total rejection of the outflow loss $c^2/2g$, the pump, equipped with a diffuser, loses the fraction f of the entire discharge velocity head relative to the system—

$$f\,\frac{(V + c_m)^2 + c_u^2}{2g}$$

When operating as a turbine, however, as represented at (c) the equivalent head (or in this case the effective head) H_e corre-

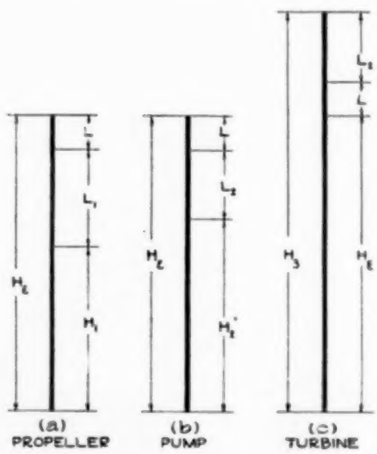

Fig. 8 Diagram Showing Relation of Heads in Propeller, Pump and Turbine

sponding to the energy transmitted by the shaft is that portion of the total initial head H_3 which remains after deducting the losses L and L_2. In all three modes of operation, we can suppose the same quantity of water to be passing through the wheel, the same power being transmitted by the shaft, and therefore the same equivalent head H_e being involved. (We can suppose the blade angles to be adjusted to keep Q the same.) Since the velocities are the same, L is constant throughout, and L_2 is the same at (b) and (c).

The efficiencies for the three cases are

$$(a)\ e_1 = \frac{H_1}{H_e}; \quad (b)\ e_2 = \frac{H_2}{H_e}; \quad (c)\ e_3 = \frac{H_e}{H_3};$$

and the specific speeds as a pump and turbine, respectively are—

$$(b)\ N_{sq} = N\frac{\sqrt{Q}}{H_2^{3/4}}; \quad (c)\ N_{sq} = N\frac{\sqrt{Q}}{H_3^{3/4}} \text{ and } N_s = N\frac{\sqrt{\text{S.Hp.}}}{H_3^{5/4}}$$

(N_{sq} indicating the specific speed based on quantity of discharge, used in pump practice and N_s the ordinary specific speed as used in turbine practice, expressed in the foot-pound system.)

The remaining steps to complete the calculation of the above results are the determination of c_m, c_u, L_1 and L_2.

In figuring either the moment of momentum or the kinetic energy of the discharge, we can assume for simplicity that the result is the

same as if the whole flow were concentrated at about seven-tenths the radius of the wheel, giving—

$$c_u = \frac{gM}{WQ\ (0.707)\ R}$$

where M is the torque or moment of tangential forces; and from—

$$c_m = \frac{gT}{WQ}$$

we obtain—

$$L_1 = \frac{c^2}{2g} = \frac{c_u^2 + c_m^2}{2g}$$

For the propeller tests used c_u is found to be small. We then have, referring to Fig. 8 (a)—

$$L = H_e - L_1 - H_1$$

$$L_2 = f\frac{(V + c_m)^2 + c_u^2}{2g}$$

results plotted are properly comparable. While the turbine performances plotted, which are indicated in solid lines, are actual test results, the curves computed from propellers, and shown in dotted lines, are inferred or theoretical values derived from the test results by the method indicated in the above analysis.

While there are a number of reservations which should be kept in mind in comparing the turbine and propeller performances to take account of some of the differences pointed out above, such, for example, as an allowance for the difference between the friction of a solid confining wall and the loss due to the turbulence of a flowing stream passing through still water, it is, however, believed that the relations presented in the chart are of considerable interest and significance. It will be noted that the general trend of the envelope representing the highest efficiencies at various specific speeds is very similar to the form of curve presented in the paper of last year by one of the authors, in which the theoretically possible efficiency was computed for various specific speeds. From the internal losses in the propeller due to blade friction, etc., the value

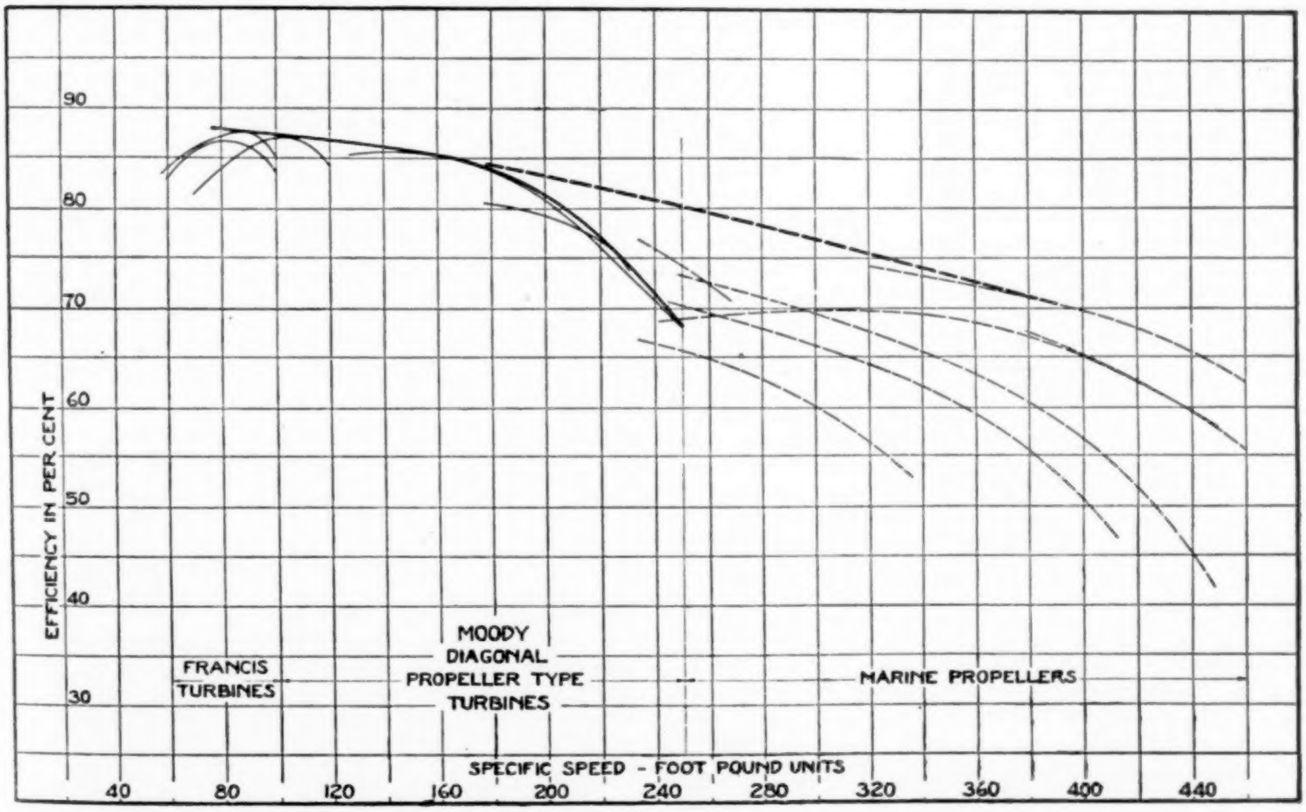

Fig. 9 Chart of Efficiency and Specific Speed for High-Speed Turbines

(using 0.20 for f), and —

$$H_3 = H_e + L + L_2$$

from which we immediately obtain e_3 and N_s.

The method of calculation formulated above has been applied numerically to the series of propellers tested by Admiral Taylor,[1] and the specific speed and efficiency corresponding to operation as a turbine have been computed for various values of slip for those models which gave the higher values of efficiency. The results are given in Fig. 9, which is a chart showing the relation between efficiency and specific speed for three ranges of specific speed, namely, the range corresponding to the turbines of the usual or so-called Francis type; the range so far covered by the high-speed propeller type; and finally the values calculated according to the above method for marine propellers operating as turbines. The turbine efficiencies shown on the chart, some of which are from recent tests, were all secured on 16-in. turbines tested in the I. P. Morris laboratory. It happens that Admiral Taylor's propeller tests were also made on wheels of 16 in. diameter, so that all of the

[1] D. W. Taylor: Some Recent Experiments at the U. S Naval Basin. Paper before Society of Naval Architects and Marine Engineers, Nov. 17–18, 1904.

of the coefficient f_2 used in last year's paper can apparently be some what reduced for the propeller-type turbines, giving a generally higher range of possible efficiences.

In addition to computing the efficiencies corresponding to various specific speeds derived from the propeller tests, the velocity head of the water at discharge from the runner and the allowance for local cavitation have also been computed and from these has been worked out the elevation at which the runner should be set with reference to tailwater in order to permit the propeller to operate as a turbine at the specific speeds shown. These results are presented in Fig. 10, which is a chart showing the relation of runner elevation to specific speed corresponding to three different values of the head on the plant selected by way of illustration. The chart shows, therefore, the probable effect of further increases in specific speed on the turbine setting. In order that these speeds may be safely realized, the values computed as above call for the turbine to be set at elevations not higher than those shown on the chart. These runner elevations are based on what the authors believe to be conservative practice within the field so far developed in actual turbines and similarly computed for the higher specific-speed field corresponding to the marine propellers. Under the higher heads and specific speeds it

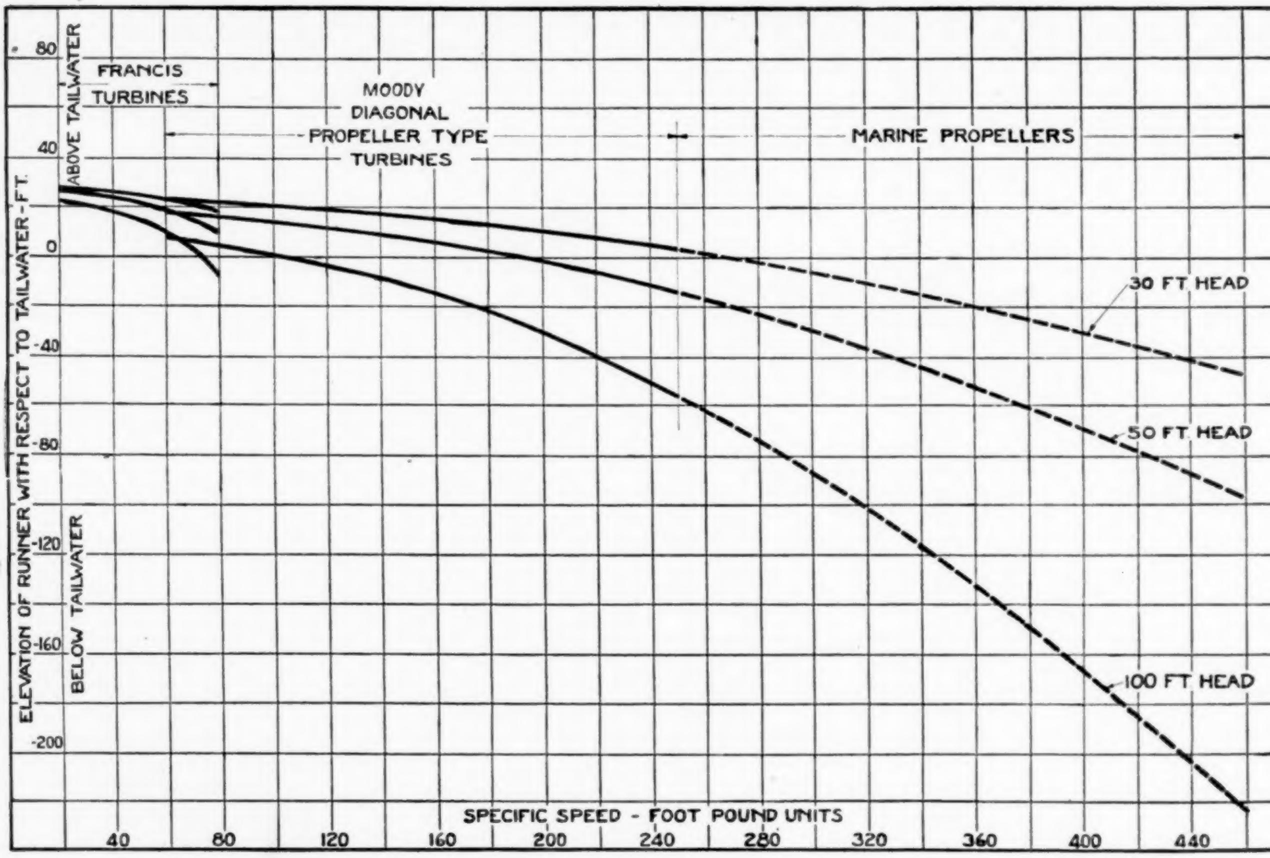

FIG. 10 CHART OF RUNNER ELEVATION AND SPECIFIC SPEED

will be noted that it would be necessary to place the runner far below tailwater and for the moderate conditions the runner would have to be placed close to the tailwater level, and in many cases somewhat below it. As has been previously shown, this is not impracticable.

It is believed that the above investigation of propeller performance throws some new light on the relation of turbine performance to that of pumps. It is also thought to be of interest to view the full range of turbine performance shown by Fig. 9, as indicated by the values of specific speed, with the corresponding values calculated for other classes of power machines. Table 1 has therefore been computed, indicating in a general and approximate way the comparative fields occupied by various machines, including hydraulic and steam turbines, pumps, air compressors and blowers, and the performance of marine propellers according to the above calculations for operation in ship propulsion, and as turbines and pumps.

TABLE 1 FIELDS OCCUPIED BY VARIOUS CLASSES OF MACHINES, COMPARED ON BASIS OF SPECIFIC SPEED

Class of Machine	Range of Specific Speeds Based on Power $N_s = N\frac{\sqrt{HP}}{H^{5/4}}$		Range of Specific Speeds Based on Quantity $N_{sq} = N\frac{\sqrt{Q}}{H^{3/4}}$
	Ft-lb. units	Metric units	Ft-lb. units
Hydraulic Turbines:			
Impulse turbines; single-nozzle Pelton wheels............	up to 8	up to 35	up to 25
Multiple-nozzle Pelton wheels or extreme low-speed Francis reaction turbines............	8 to 11	35 to 50	25 to 35
Reaction turbines, Francis type	11 to 95	50 to 425	35 to 300
Do., propeller type..........	95 to 225	425 to 1000	300 to 750
Pumps:			
Centrifugal (per stage)........	......	......	35 to 350
Screw or propeller type...... ...	......	......	350 to 600
Air compressors and centrifugal blowers................	......	......	100 to 900 (*a*,*b*)
Cone- and propeller-type fans..	......	......	900 to 4000 (*b*)
Steam Turbines:			
Last stage....................	about 0.13	about 0.60	50 to 90 (*a*)
Marine Propellers:			
Operating as propellers........	......	......	2600 to 3700
Operating as pumps (inferred performance)..............	......	......	1600 to 3000
Operating as turbines (inferred performance)..............	240 to 440	1070 to 2000	800 to 1600

(*a*) Based on values from article by K. Baumann entitled, Some Recent Developments in Large Steam-Turbine Practice, in *Engineering* (London), April and May, 1921. (*b*) Based on values from article by M. C. Stuart entitled, Centrifugal Fan Calculations by the Specific-Speed Method, in *Jl. Am. Soc. Naval Engrs.*, vol. 28, no. 3, August, 1916.

For the purpose of comparing prime movers, and pumps or compressors, the specific speed based on quantity has been used, as was done in the paper (The Present Trend of Turbine Development) delivered last year. The values given in the table are necessarily approximate, and are merely expressed in round numbers, since there are no exact limits to the specific speeds developed by a given class of machines, and the values stated meerly indicate those corresponding to the field of normal design.

The values shown on the chart of Fig. 9 seem to hold out much promise for further increases of very appreciable amounts in turbine speeds, for they show sufficiently high efficiencies to make the use of considerably higher speeds feasible, particularly in low-head plants where a saving in cost of machinery often justifies a sacrifice in efficiency. While the chart suggests the possibility of increases in speeds, the authors believe that the application of such increases should be made with caution and particularly that the extension of the use of these high-speed turbines to higher heads should be limited to the range of specific speeds for which high efficiencies have been actually developed by tests. Low efficiency points to the presence of eddies and disturbances in the turbine and should be regarded as a danger signal. Even when efficiency is not a vital consideration in itself (which is seldom true), low efficiency provokes other troubles which may be serious. In the authors' judgment, therefore, the utilization of still higher speeds, which from the above investigation would appear to be attainable, should be made contingent upon the development of high efficiencies.

Semi-steel is the name popularly applied to the metal resulting from the use of mild steel added to the pig irons and scrap melted in the cupola or furnace. The percentage of steel used varied from 15 to 40 per cent, the lower figure for light work and the higher proportions for heavier castings. It is stronger than usual gray cast iron as regards transverse, tensile, compression and impact tests. It is superior in regard to elasticity, toughness, resistance to shock and wear. It has proved satisfactory for such castings as cylinders, pistons, gear wheels and castings called upon to withstand wear and friction. J. Cameron, in *The Engineer* (London), Aug. 11. 1922, p. 149.

High-Pressure Steam-Heating Lines

Effect of Throttling Through a Reducing Valve or Steam Motor—Economy of Generating Steam at High Pressure and Transmitting It Through a Small Line with Large Line Drop

By EDGAR BUCKINGHAM,[1] WASHINGTON, D. C.

A LETTER recently[2] referred to the writer contained the following requests for information: "We should be pleased to have such advice and references as to permit of our estimating the economy in steam production on a large scale which would be occasioned by generating and delivering steam for vulcanization at 45 lb. per sq. in. as compared with generating at 190 lb. per sq. in. and delivering at the lower pressure mentioned by throttling through a reducing valve." "Would not a steam engine or turbine, for example, functioning as a reducing valve between 190 and 45 lb. per sq. in. deliver a considerable power output without appreciably reducing the heat-supplying power of the low-pressure steam as compared with the ordinary reducing valve?" "When steam is used for purely heat-supplying purposes, does the use of a reducing valve over a considerable pressure range involve any real efficiency loss, or does the superheat due to throttling bring the available energy practically back to its original status?"

The engineer to whom the reply was sent wrote: "The conclusions you have reached are indeed surprising, and I trust that you will find the opportunity to prepare them for publication." Without knowing whether the conclusions in question are really novel, the writer submits the substance of his reply in the hope that if these deductions from very elementary principles are known by experiment to be incorrect, the facts may be brought out, for the public benefit, by some one who knows what the facts are.

The Nature of the Throttling Process

The throttling process does not in itself cause any change in the "total heat" of the steam; and if the steam is to be used solely for heating purposes, i.e., only as a carrier for heat, the use of a reducing valve has no direct effect on the economy of the process, although there may, of course, be indirect effects on boiler efficiency and line losses, caused by the difference between generation and transmission at high pressure and at low.

The simplest way to look at the matter is as follows: We start with water at 45 lb. per sq. in. gage (60 lb. per sq. in. abs.) and the corresponding boiling point which is 292.7 deg. fahr. We put heat into this water in the boiler; convert it into steam at any pressure we please above 45 lb. per sq. in.; run it through a transmission line to a different place; condense it to water at the original temperature and pressure; and finally feed it back into the boiler.

During this process, aside from the insignificant work of the boiler-feed pump, no outside work is done either on or by the steam. Frictional work against the line resistance is merely dissipated into heat which stays in the steam, and does not count as outside work. A sudden large drop through a reducing valve is precisely equivalent to a great amount of line resistance concentrated in a short length of line. No *outside* work is done, and the kinetic energy generated at the valve is dissipated into heat which stays in the steam and dries or superheats it.

Since, therefore, the steam, in going round its closed cycle and returning to its original state of water at 45 lb. per sq. in. gage and 292.7 deg. fahr., does no outside work and has none done on it, the total amount of heat put into it must also be zero; otherwise the steam could not return to its initial state.

It follows that the heat put into the water in the boiler (plus the small heat equivalent of the work of the feed pump) is equal to the sum of the heat loss to the outside and the heat given up in the condenser—in this case the vulcanizer. This remains true no matter what the upper pressure may be, so that the economic questions to be considered in deciding on what pressure to use, relate to boiler efficiency, heat losses, and overhead.

If the steam is generated at an unnecessarily high pressure, which requires reduction before the steam is admitted to the vulcanizer, the reducing valve may be replaced by a steam engine or turbine. This will give a certain amount of outside work and the heat remaining in its exhaust to be given up in the vulcanizer, will be correspondingly diminished. If the bearing losses of the motor all stayed in the steam, the reduction in the heating value of the steam by its passage through the motor would be exactly the heat equivalent of the work delivered by the motor outside the bearings. Bearing losses which do not go back into the steam as reheat are equivalent to so much heat lost to the outside. They are to be added into the heat loss from the motor, which is itself merely one element of the heat loss from the whole system.

Calculations Dealing with Throttling in the Line

To illustrate quantitatively, we will suppose that the vulcanizer requires 1,000,000 B.t.u. per hour, which are to be given up by steam at 45 lb. per sq. in. gage condensing at its saturation temperature of 292.7 deg. fahr. We shall consider three cases: (*a*) generation and transmission at 45 lb. per sq. in. gage; (*b*) generation and transmission at 190 lb. per sq. in. gage, with throttling to 45 lb. per sq. in.; (*c*) the same as (*b*) with the substitution of a reciprocating engine or turbine for the reducing valve. We shall suppose, in each case, that the boiler furnishes dry saturated steam, and we shall neglect pressure drop in the transmission line, and heat losses to the outside. Numerical data on steam are from the Marks and Davis tables.

In case (*a*), dry steam at 45 lb. (60 lb. per sq. in. abs.) arrives at the vulcanizer. Its latent heat is 914.9 B.t.u. per lb., so that the amount of steam needed is—

$$M_a = 10^6/914.9 = 1093 \text{ lb. per hour}$$

The furnace has, in any case, to supply to the water the whole 10^6 B.t.u. per hour plus the outside heat loss. The work of the feed pump would be zero if there were no line drop, and is insignificant in any event.

Turning to case (*b*), the total heat of water at 45 lb. per sq. in. gage and its saturation temperature 292.7 deg. fahr. is $H_0 = 262.1$ B.t.u. per lb. The total heat of dry saturated steam at 190 lb. per sq. in. gage and 384 deg. fahr. is $H_1 = 1198.5$. The heat supplied in the boiler is therefore $H_1 - H_0 = 936.4$ B.t.u. per lb. This difference consists of 95 B.t.u. per lb. needed to heat the water from 292.7 deg. to 384 deg., and 841.4 B.t.u. per lb. which is the latent heat of evaporation at 190 lb. per sq. in. gage. If there are no heat losses, the 936.4 B.t.u. per lb. are available for heating the vulcanizer, so that the amount of steam needed is—

$$M_b = 10^6/936.4 = 1068 \text{ lb. per hour}$$

When the dry saturated steam at 190 lb. is throttled to 45 lb. its temperature falls to 334.7 deg., but it is superheated 42 deg. Before beginning to condense, it must cool to 292.7 deg., and in so doing it gives up 936.4 − 914.9 = 21.5 B.t.u. per lb. in addition to the 914.9 which it will give up as latent heat of condensation. To put it in another way, the dry steam at 190 lb. carries 936.4/914.9 = 1.024 times as much heat available for extraction at 45 lb. as does dry steam at 45 lb.; so that the amount needed is only 1093/1.024 = 1068 lb. per hour.

In case (*c*), if the dry saturated steam at 190 lb. per sq. in. gage were to expand isentropically to 45 lb. its total heat would fall from 1198.5 to 1102.1 and the difference, or 96.4 B.t.u. per lb., is the "available heat drop" which could be turned into outside work by an ideally perfect motor. The dryness factor of the steam after this expansion through a perfect engine would be 0.918; and the heat remaining available upon condensing to water would be 0.918 × 914.9 = 840.0 B.t.u. per lb. which added to the 96.4 makes up the 936.4 originally available.

Supposing that the motor extracts, say, 0.6 of the maximum possible—corresponding to 60 per cent indicated efficiency in the

[1] Physicist Bureau of Standards. Mem. Am.Soc.M.E.

[2] This was written in July, 1920.

case of a reciprocating motor—the heat drop of the steam in passing through the motor will be 0.6 × 96.4 = 57.8 B.t.u. per lb., so that the total heat of the exhaust is 1198.5 − 57.8 = 1140.7 B.t.u. per lb. And since the total heat of water at 45 lb. is 262.1, the heat available in the exhaust for use in the vulcanizer is 1140.7 − 262.1 = 878.6 B.t.u. per lb., the dryness factor of the exhaust being 878.6/914.9 = 0.960.

The amount of steam needed in this case would be, for a motor of 60 per cent indicated efficiency,

$$M_c = 10^6/878.6 = 1138 \text{ lb. per hour}$$

as compared with M_b = 1068 when a reducing valve was used. The indicated power of the motor would be 1138 × 57.8/2543 = 25.9 hp.

The pump work needed to put the condensate at 45 lb. back into the boiler at 190 lb. is less than 0.5 B.t.u. per lb., so that we have been justified in ignoring it.

Pressure Drop and Heat Loss in the Transmission Line

We may now turn to the question of pressure drop and heat loss in the transmission line, and we shall assume that no motor is to be used so that we have only to compare generation and transmission at a trifle above 45 lb. per sq. in. gage, with generation and transmission at 190 lb. followed by throttling to 45 lb. Leaving aside the question of capital charges, we shall consider only the heat losses per foot length of the transmission line, assuming that the different lines are all equally well insulated. We may say, as an approximate rule for practical purposes, that the heat loss per foot of pipe in B.t.u. per hour will be proportional to the diameter of the pipe and to the difference between the steam temperature and the temperature of the surroundings.

From this rule it is evident that increasing the pressure (and temperature) of the steam in the line increases the heat loss from a line of given size. But if the high-pressure line can be made small enough the reduction in surface will more than offset the increase of temperature difference, so that the losses may be less at the high pressure. The question, then, is whether the high-pressure line can be made small enough.

We here come to an essential difference between heating lines and power lines. In designing a power line the pressure drop along the line, which is merely distributed throttling, must be kept low because throttling diminishes the available heat drop that remains for the motor to work on. But in a high-pressure heating line followed by a reducing valve this limitation on the design is absent; for, aside from the heat losses, it makes no difference at all whether the necessary throttling takes place at a reducing valve or is distributed along the transmission line as line drop. The line drop may therefore be made large, leaving only enough drop at the reducing valve to take care of overload.

This plan seems to present several advantages. In the first place, the line can be made small and its surface reduced. Then the wire drawing in the line tends to dry or superheat the steam, which, of itself, reduces the ease of transmission of heat from the steam to the pipe. Moreover, the wire drawing, while it superheats the steam, reduces its temperature and so again decreases the heat loss. It appears, therefore, that a high-pressure heating line should be designed on entirely different principles from a power line. The line should be as small in diameter as practicable, the limit being set either by the necessity of having some drop remaining at the reducing valve, or, more probably, by the erosion of the line, which may become troublesome when the steam speed is run up very high.

Illustrative Computations of Pressure Drop and Heat Loss

It may be worth while to make some sample computations to illustrate the foregoing. Let D equal the inside diameter of the pipe in ft., S the linear speed of the steam in ft. per sec., M the mass flow in lb. per hour, and v the specific volume of the steam in cu. ft. per lb. Then we have—

$$M = 3600\,\frac{\pi}{4}\,D^2\,\frac{S}{v} = 2827\,\frac{D^2S}{v} \text{ lb. per hour} \quad \text{[1]}$$

whence—

$$S = (Mv/2827D^2) \text{ ft. per sec.} \quad \text{[2]}$$

Let P be the pressure drop per foot length of the line. Then since the steam speed is to be high so that the resistance is nearly proportional to the square of the speed, we have, approximately,

$$P = \text{const.} \times S^2/Dv \quad \text{[3]}$$

where the value of the constant depends on the roughness of the pipe line as well as on the unit used for P. Eliminating S we have—

$$P = \text{const} \times M^2v/D^5 \quad \text{[4]}$$

whence—

$$D = \text{const.} \times (M^2v/P)^{1/5} \quad \text{[5]}$$

To use this equation for designing purposes we should have to take a value of the constant from known experimental results; but for our present purpose of comparing different sets of conditions we only need to assume that it is the same for the different lines compared; i.e., that the lines are similarly rough. If the subscripts 1 and 2 refer to the two sets of conditions, we then have for the ratio of the pipe diameters—

$$\frac{D_1}{D_2} = \left\{\left(\frac{M_1}{M_2}\right)^2 \times \frac{v_1}{v_2} \times \frac{P_2}{P_1}\right\}^{1/5} \quad \text{[6]}$$

an equation which we may proceed to apply to numerical examples.

Let our two sets of conditions be: transmission at 45 lb. per sq. in. gage; and transmission at 190 lb. followed by throttling to 45 lb. We have already found in an earlier paragraph that M_{45}/M_{190} = 1093/1068; and from the steam tables we find that v_{45}/v_{190} = 7.17/2.237. Substituting these values in Equation [6] we have—

$$\frac{D_{45}}{D_{190}} = 1.26\left\{\frac{P_{190}}{P_{45}}\right\}^{1/5} \quad \text{[7]}$$

Equation [7] tells us that if the line drop is to be the same in both lines so that $P_{45} = P_{190}$, the diameter of the low-pressure line must be 1.27 times that of the high-pressure line. The steam temperatures are 384 deg. and 293 deg., respectively, and if we assume an outside temperature of, say, 80 deg. we shall have approximately—

$$\frac{\text{heat loss at 45 lb.}}{\text{heat loss at 190 lb.}} = 1.26 \times \frac{293 - 80}{384 - 80} = 0.89$$

Hence if the lines were designed for equal total line drop, the low-pressure line, under ordinary outside conditions, would lose something like 10 per cent less heat than the high-pressure line.

But suppose that we let the drop be 10 times as great in the high- as in the low-pressure line, so that $P_{190} = 10P_{45}$. Then Equation [7] gives us D_{45}/D_{190} = 2.02, and in this case for 80 deg. outside temperature we have approximately—

$$\frac{\text{heat loss at 45 lb.}}{\text{heat loss at 190 lb.}} = 2.02\,\frac{293 - 80}{384 - 80} = 1.41$$

so that the heat loss would be considerably less for the *high*-pressure line. The figures are, of course, only roughly approximate, but they suffice to show the advantage of using high-pressure transmission with a small pipe and large line drop, altogether aside from questions of the capital cost of the line.

Although we have no precise data which would enable us to estimate the probable change in the combined furnace and boiler efficiency caused by changing from low to high pressure, it would seem, in view of the foregoing reasoning, that unless the transmission line is very short, a properly designed high-pressure plant may be made decidedly more economical in operation than a low-pressure one for the same heat supply to the vulcanizer.

Summary

The information requested may be summarized as follows:

a The use of a reducing valve in a steam-heating line does not, in itself, have any effect on the economy of the heating.

b If a steam motor is substituted for the reducing valve, the heating value of its exhaust is decreased by the amount of heat turned into work by the motor.

c Line drop is merely distributed throttling and has no direct effect on the final heating value of the steam.

d By generating at high pressure and transmitting through a small line, with large line drop, the heat loss from the line may be made much smaller than when the pressure is low throughout the system.

Forces in Rotary Motors

A Paper Dealing with the Determination of the Forces in a Rotary Motor Caused by the Reciprocation of the Pistons and Connecting Rods and by the Rotation of the Motor as a Whole, in Which Novel Methods of Calculation Are Employed

By KARL H. WHITE,[1] KEYPORT, N. J.

THE object of this paper is to present methods of determining the turning effort and the inertia and shaking forces of the pistons and connecting rods in a rotary motor, the LeRhone 9-cylinder 80-hp. internal-combustion motor being used as a concrete example. The data on this motor are given in Table 1.

The Indicator Card

From the data given in Table 1 the indicator card shown in Fig. 1 may be implied.

$$V = \frac{667}{9} = 74.11 \text{ cu. in.}$$

$$\text{Clearance} = \frac{74.11}{4.8} = 15.43 \text{ cu. in.}$$

Total volume of cylinder = 89.54 cu. in.

In Fig. 1—

$$\frac{P_b}{P_a} = \left(\frac{V_a}{V_b}\right)^n$$

Assuming an intake pressure of 13 lb. per sq. in. and $n = 1.35$ according to good practice,

$$\frac{P_b}{13} = \left(\frac{89.54}{15.43}\right)^{1.35}, \quad \text{whence } P_b = 139.8 \text{ lb. per sq. in.}$$

It can be shown theoretically that the mean effective pressure is equal to—

$$P_m = \frac{P_x V_x - P_x \dfrac{P_a}{P_b} V_d - P_b V_x + P_a V_d}{(n-1)(V_d - V_x)}$$

Substituting known values and employing a card factor of 0.96,

$$\frac{84}{0.96} = \frac{15.43P_x - \dfrac{13 \times 89.54P_x}{139.8} - 139.8 \times 15.43 + 13 \times 89.54}{0.35\,(89.54 - 15.43)}$$

whence—

$$P_x = 459 \text{ lb. per sq. in.}$$

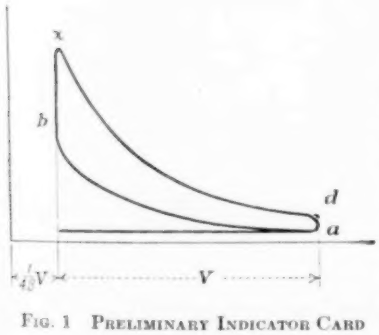

Fig. 1 Preliminary Indicator Card

The equation PV_n = Constant may be plotted as a straight line with a slope n on logarithmic cross-section paper. Plotting the compression and expansion curves in this manner the pressure P_d at d may be obtained from the expansion curve, as the pressure P_x at x and slope n are given.

TABLE 1 DATA ON THE LE RHONE 9-CYLINDER 80-HP. MOTOR INVESTIGATED

Speed	1200 r.p.m.
Direction of rotation	Normal (counterclockwise from propeller end).
Bore of cylinders	4.1339 in.
Stroke	5.512 in.
Length of connecting rods	9.6458 in.
Compression ratio	4.8
Piston displacement (9 cylinders)	667 cu. in.
Order of firing	1, 3, 5, 7, 9, 2, 4, 6, 8
Mean effective pressure	84 lb. net
Weight of engine dry	245 lb.
Weight of engine in running order, less fuel, oil and tanks	270 lb.
Weights of parts:	
Piston, with piston rings (each)	1.727 lb.
Wristpin with wristpin retainer screw	0.363 lb.
Inner connecting-rod assembly (each)	1.203 lb.
Center connecting-rod assembly (each)	1.240 lb.
Outer connecting-rod assembly (each)	1.340 bl.

[1] Airplane Engineering Dept., The Aeromarine Plane & Motor Co. Abridgment of paper awarded the A.S.M.E. Student Prize for 1921.

The theoretical and actual indicator card may now be constructed as shown in Fig. 2.

Inertia Forces of Pistons and Connecting Rods

In order to obtain the inertia forces of the pistons and connecting rods, it is first necessary to obtain the absolute accelerations of these parts, because $F = MA$, where F = inertia force, M = mass, and A = absolute acceleration.

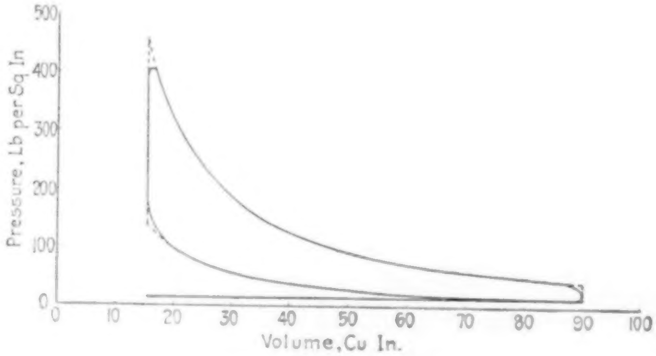

Fig. 2 Indicator Card for LeRhone 80-Hp. Motor
(Theoretical card also includes dotted areas.)

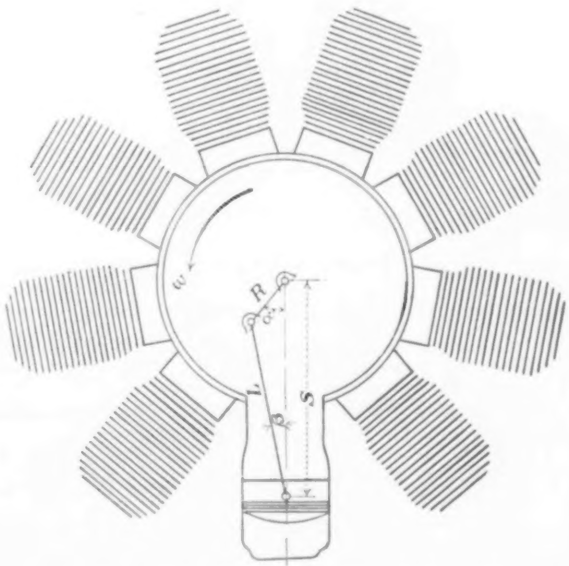

Fig. 3 Diagrammatic View of One Connecting Rod of LeRhone 80-Hp. Motor

Inertia of Pistons. The absolute acceleration of the piston is rather complicated, but may be found by using Coriolis' law.[1] According to this law, the absolute acceleration may be divided into three parts:

a The acceleration of a point on the cylinder opposite the center of gravity of the piston toward the center of rotation $= S\omega^2$. See Fig. 3.

b The acceleration of the piston relative to the cylinder, $= dS/dt$.

c Twice the product of the velocity of the piston relative to the cylinder, (U), and the angular velocity, $= 2U\omega$.

From Fig. 3, it will be seen that—

[1] See Kinematics and Kinetics of Machinery, by Dent and Harper.

$$S = R \cos \alpha + L \cos \beta$$

also $\quad \sin \beta = \dfrac{R}{L} \sin \alpha$

hence $\quad \cos \beta = \sqrt{1 - \dfrac{R^2}{L^2} \sin^2 \alpha}$

Since $(R/L)^2 \sin^2 \alpha$ is a small term, we may write with sufficient accuracy—

$$\cos \beta = \sqrt{1 - \frac{R^2}{L^2} \sin^2 \alpha} = 1 - \frac{R^2}{2L^2} \sin^2 \alpha$$

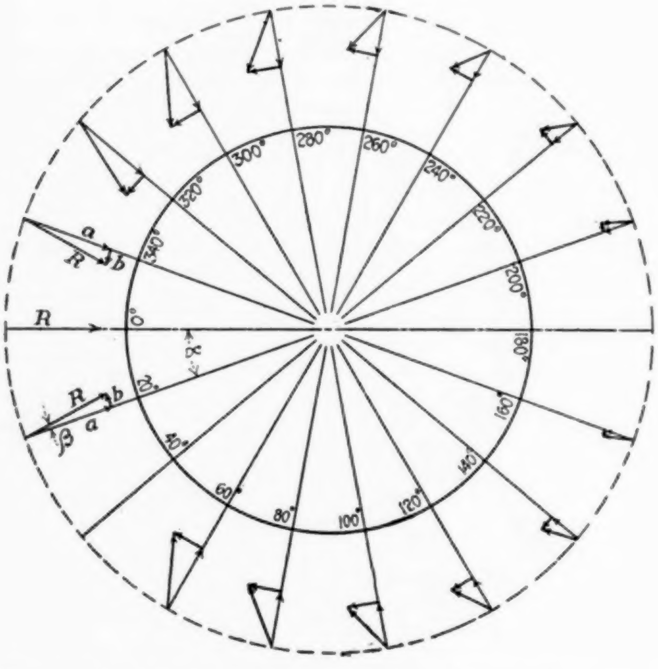

FIG. 4 ACCELERATION DIAGRAM OF PISTON, SHOWING DIRECTION OF RESULTANT

This is equivalent to adding the small quantity $\dfrac{R^4}{4L^4} \sin^4 \alpha$ under the radical.

Substituting this value for $\cos \beta$,

$$S = R \cos \alpha + L\left(1 - \frac{R^2}{2L^2} \sin^2 \alpha\right) \qquad [1]$$

The velocity of the piston relative to the cylinder is—

$$\frac{dS}{dt} = U = -R\,\omega\left(\sin \alpha + \frac{R}{2L} \sin 2\,\alpha\right) \qquad [2]$$

The second derivative of S with respect to time is equal to the acceleration of the piston relative to the cylinder, or—

$$\frac{d^2S}{dt^2} = -R\,\omega^2\left(\cos \alpha + \frac{R}{L} \cos 2\,\alpha\right) \qquad [3]$$

The negative sign simply indicates the direction of the acceleration.

Let us now rotate the motor through one revolution and consider accelerations every ten degrees.

Crank length = 0.2297 ft.

Length of connecting rod = 0.8038 ft.

$$1200 \text{ r.p.m.} = \frac{2\pi \times 1200}{60} = 126 \text{ radians per sec.} = \omega$$

From Equation [1]—

$$S = 0.2297 \cos 10° + 0.8038\left(1 - \frac{0.2297^2}{2 \times 0.8038^2} \sin^2 10°\right)$$

$$= 1.027 \text{ ft.}$$

From Equation [2]—

$$U = 0.2297 \times 126\left(\sin 10° + \frac{0.2297}{2 \times 0.8038} \sin 20°\right)$$

$$= 6.45 \text{ ft. per sec.}$$

From Equation [3]—

$$\frac{d^2S}{dt^2} = \frac{dU}{dt} = 0.2297 \times 126^2\left(\cos 10° \frac{0.2297}{0.8038} \cos 20°\right)$$

$$= 4575 \text{ ft. per sec.}^2$$

$$S\omega^2 = 1.027 \times 126^2 = 16{,}300 \text{ ft. per sec.}^2$$

$$2U\omega = 2 \times 6.45 \times 126 = 1625 \text{ ft. per sec.}^2$$

From Coriolis' law, $2\,U\omega$ is at right angles to $S\omega^2$ and $\dfrac{dU}{dt}$, and the absolute acceleration R of the piston is the vector sum of these three quantities.

As $S\omega^2$ and $\dfrac{dU}{dt}$ are in the same direction at this position of the motor,

$$R = \sqrt{\left[(S\omega^2) + \frac{dU}{dt}\right]^2 + (2U\omega)^2}$$

$$= \sqrt{(16{,}300 + 4{,}575)^2 + 1625^2}$$

$$= 20{,}900 \text{ ft. per sec.}^2$$

R may be determined graphically, however, with sufficient accuracy.

TABLE 2 ACCELERATIONS OF PISTON BY CORIOLIS' LAW

α Deg.		S ft.	U ft./sec.²	$S\omega^2$ ft./sec.²	$\dfrac{dU}{dt}$ ft./sec.²	$2U\omega$ ft./sec.²	R ft./sec.²	$S\omega^2$ + or − $\dfrac{dU}{dt}$
0		1.033	0	16420	4690	0	21110	21110
10	350	1.027	6.45	16300	4575	1625	20925	20875
20	340	1.011	12.57	16050	4220	3170	20500	20270
30	330	0.985	18.07	15650	3650	4550	19800	19300
40	320	0.952	22.70	15120	2970	5720	18975	18090
50	310	0.912	26.20	14480	2160	6600	17900	16640
60	300	0.870	28.65	13800	1300	7220	16750	15100
70	290	0.824	29.90	13070	448	7530	15450	13518
80	280	0.780	29.95	12400	−346	7550	14250	12050
90	270	0.738	28.95	11720	−1042	7300	12950	10678
100	260	0.700	27.10	11100	−1610	6840	11750	9490
110	250	0.667	24.55	10600	−2020	6180	10600	8580
120	240	0.640	21.50	10180	−2340	5420	9600	7840
130	230	0.616	18.10	9780	−2520	4560	8600	7260
140	220	0.599	14.50	9500	−2600	3660	7850	6900
150	210	0.588	10.90	9350	−2640	2750	7300	6700
160	200	0.580	7.23	9210	−2630	1820	6850	6580
170	190	0.575	3.62	9130	−2610	912	6600	6520
180		0.574	0.0	9100	−2605	0	6505	6505

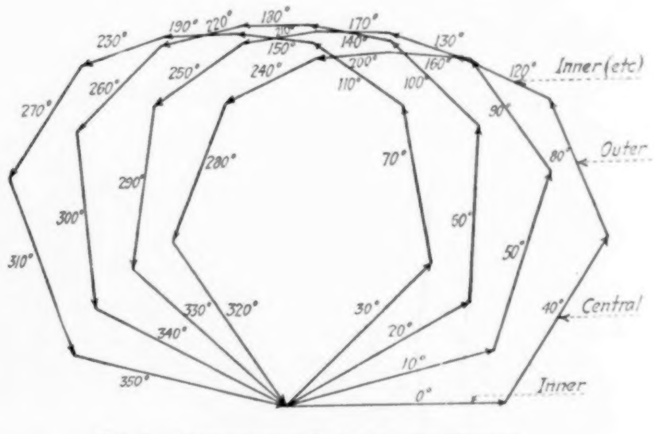

FIG. 5 ACCELERATION POLYGONS FOR PISTONS

In a similar manner the absolute acceleration of the piston is found for every 10 deg. rotation of the motor, the results being given in Table 2.

Fig. 4 is an acceleration diagram of the piston showing the direction of its absolute acceleration. If we now plot acceleration polygons of the pistons at any particular position of the motor, we can determine the amount and direction of any shaking force due to the inertia of these pistons. Such polygons are plotted in Fig. 5; the vectors representing the absolute accelerations of the nine pistons at the particular instants of rotation of 0, 10, 20, and 30 deg. The polygons are similar to inertia polygons because the masses of the pistons are constant. From this figure it is seen that there are no unbalanced piston inertia forces, and consequently

no shaking force coming from the reciprocation of the pistons. This figure shows the magnitude of the compound supplementary acceleration, which has heretofore been neglected in similar calculations.

Let us now determine the actual inertia force of the piston per square inch of piston area and plot this force on an indicator diagram.

The total weight of a piston is 2.090 lb.

The inertia force at any instant equals 2.09/32.2 times the acceleration of the center of gravity of the piston along the line of stroke at that particular instant. The center of gravity of the piston assembly is considered at the center of the piston pin.

In Table 3 this inertia force is given for every 10 deg. rotation of the motor.

TABLE 3 INERTIA FORCE OF PISTON
(Piston area = 13.42 sq. in.)

θ Deg.		$S\omega^2 \pm \frac{dU}{dt}$ ft./sec.^{2}	Total inertia of piston, lb.	Inertia force, lb./sq. in.
0		21110	1370	102.0
10	350	20875	1355	101.0
20	340	20270	1315	98.0
30	330	19300	1250	93.2
40	320	18090	1173	87.4
50	310	16640	1080	80.5
60	300	15100	980	73.0
70	290	13518	877	65.3
80	280	12054	782	58.2
90	270	10678	692	51.5
100	260	9490	616	45.8
110	250	8580	556	41.4
120	240	7840	508	37.8
130	230	7260	471	35.0
140	220	6900	447	33.3
150	210	6710	435	32.4
160	200	6580	427	31.8
170	190	6520	423	31.5
180		6505	422	31.4

Fig. 6 is a total-pressure diagram of a piston developed on a base line, representing the total motion of the piston relative to the cylinder (disregarding reversals) in two revolutions of the motor. In this diagram gaseous forces tending to help the motion of the piston and inertia forces tending to resist the motion of the piston are plotted above the base line. Gaseous forces tending to resist the

of gravity. The connecting rods are accordingly laid out full size and sections are taken at intervals. The area of each section is calculated and plotted as an ordinate from a base line. The areas of the figures obtained represent the volumes of the connecting rods. Fig. 7 shows the layout for the inner connecting rod.

The area of each section is now multiplied by its distance from the end of the connecting rod, and this product, which is the moment

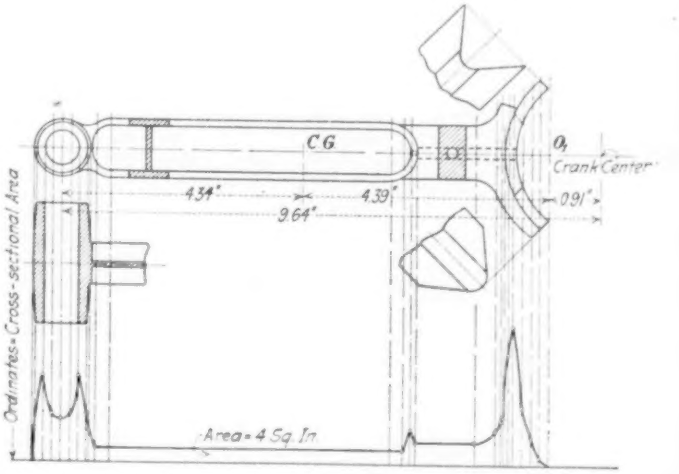

Fig. 7 Inner Connecting Rod and Volume Diagram

of that area about the end of the rod, is plotted as an ordinate from a base line. If each of these last areas obtained be divided by the first areas, the distances of the centers of gravity from their respective connecting-rod ends are determined. The center of gravity as found for the inner rod is shown in Fig. 7.

Let us now consider the accelerations of the connecting rods. From Fig. 7 the center of gravity of the inner connecting rod is 55 per cent of the distance from the crank center to the center of the piston pin. Therefore the acceleration of the center of gravity of

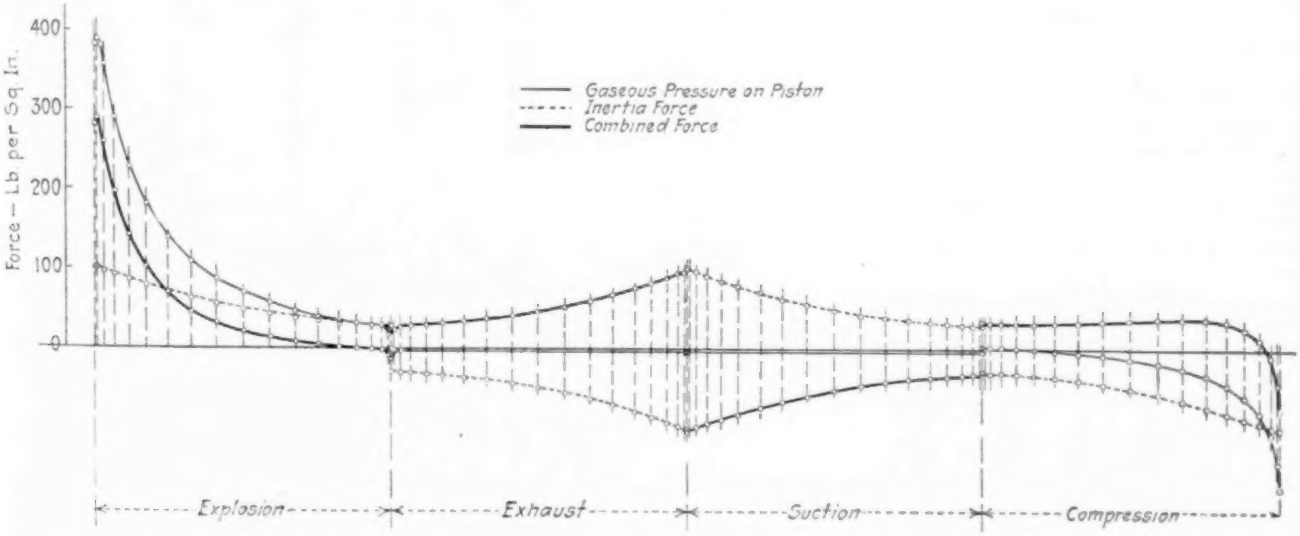

Fig. 6 Diagram of Gaseous Pressure on Piston, of Inertia Force of Piston, and of Combined Gaseous and Inertia Forces

motion of the piston and inertia forces tending to help the motion of the piston are plotted below the base line. These two force curves are combined to represent the resultant net piston force, as shown by the heavy lines. The resultant net piston force is plotted above the base line if tending to help the motion of the piston, and below if tending to resist the motion of the piston.

Fig. 6 shows that due to the inertia of the piston there is as much work done on the exhaust stroke as on the explosion stroke. It also shows that the inertia force compresses the gas on the compression stroke. On the other hand, during the explosion and suction strokes this inertia greatly hinders the motion of the piston.

Inertia of Connecting Rods. In order to determine the inertia forces of the connecting rods, it is first necessary to find their centers

this connecting rod is 0.55 times the acceleration of the piston and lies in the same direction at any instant. Similarly, the accelerations of the central and outer connecting rods are found to be respectively 0.548 and 0.53 times the acceleration of the piston, and in the same direction.

The accelerations and inertia forces of the connecting rods for every 10 deg. rotation of the motor are given in Table 4.

Knowing the magnitude and direction of these inertia forces, an inertia polygon may be plotted showing the resultant unbalanced inertia force of the connecting rods at any instant. Such a polygon is shown in Fig. 8 for angles of rotation of 0, 10, 20 and 30 deg. Due to the difference in weights of the connecting rods, the polygons do not quite close.

TABLE 4 ACCELERATIONS AND INERTIA FORCES OF CONNECTING RODS

α Deg.		Accelerations, Ft./per Sec.² Inner	Central	Outer	Inertias, Lb. $M = 0.0372$ Inner	$M = 0.0385$ Central	$M = 0.0416$ Outer
0		11600	11580	11190	432	446	465
10	350	11500	11480	11100	428	442	462
20	340	11270	11250	10870	419	433	453
30	330	10900	10850	10500	406	417	437
40	320	10430	10400	10050	388	400	418
50	310	9850	9830	9490	366	378	394
60	300	9220	9200	8870	343	354	369
70	290	8500	8480	8190	316	327	341
80	280	7840	7820	7550	292	301	314
90	270	7125	7100	6860	265	273	285
100	260	6460	6440	6225	240	248	259
110	250	5830	5810	5620	217	224	234
120	240	5280	5260	5080	196	202	211
130	230	4730	4710	4560	176	181	190
140	220	4320	4300	4160	161	166	173
150	210	4020	4000	3870	150	154	161
160	200	3770	3750	3630	140	144	151
170	190	3630	3620	3500	135	139	145
180		3580	3560	3450	133	137	143

Turning Effort

The turning effort of a rotary motor, according to the manner in

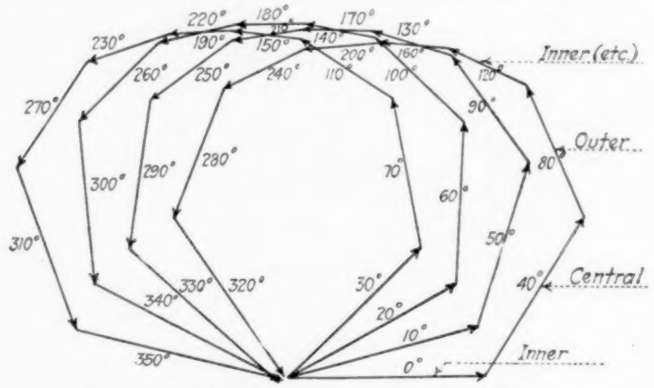

Fig. 8 Inertia Polygons of Connecting Rods

which this paper is planned, is dependent upon three separate forces:

1 The net force on the piston acting toward the center of rotation and transmitted along the connecting rod.

2 The compound supplementary inertia force $2U\omega m$, which, according to Coriolis' law, acts at right angles to the velocity of the piston and in such a direction that it tends to rotate the velocity vector of the piston in the direction of rotation of the motor.

3 The inertia force of the connecting rod acting in the same direction as the resultant inertia force of the piston.

By simply determining now the moment arm of the first two forces, we have that much of the turning effort; but in order to get the turning effort caused by the third force, it is first necessary to get the moment of inertia of the connecting rod about its center of gravity.

Moment of Inertia and Radius of Gyration of Connecting Rods. If the ordinates of the moment diagram mentioned earlier be multiplied by their distances from the ends of the connecting rods, and these products be plotted as ordinates on another base line, the area formed is the moment of inertia, I_0 of that connecting rod about its end 0, for:

$$I_0 = \Sigma MX^2 \text{ or } \Sigma VX^2.$$

From such a diagram it is found that for the inner connecting rod

$$I_{01} = 123.74 \text{ volume inches}^2$$

Also—

$$I_g = I_0 - Vh_3^2 = Vk^2$$

where I_g = moment of inertia about the center of gravity
V = volume of connecting rod
k = radius of gyration
h_3 = distance from center of gravity to point about which the moment of inertia is taken.

From Figs. 7 and 9—

$$I_g = 123.74 - 4 \times 4.39^2 = 46.54 \text{ volume inches}^2$$

$$k^2 = 11.635 \text{ sq. in.}$$

Similarly, for the central rod,

$$I_g = 43.83 \text{ volume inches}^2;\ k^2 = 10.28 \text{ sq. in.}$$

and for the outer rod,

$$I_g = 40.98 \text{ volume inches}^2;\ k^2 = 8.196 \text{ sq. in.}$$

TABLE 5 INERTIA OF KINETICALLY EQUIVALENT SYSTEM

α Deg.		Acceleration of m_2 ft. per sec.² Inner	Central	Outer	Inertia of m_2, lb. $F = 0.00263A$ Inner	$0.00282A$ Central	$0.00316A$ Outer
0		16420	15880	14700	43.2	44.7	46.5
10	350	16300	15720	14580	42.8	44.4	46.0
20	340	15960	15400	14280	42.0	43.4	45.1
30	330	15410	14900	13800	40.5	42.0	43.6
40	320	14780	14270	13210	38.8	40.2	41.8
50	310	13940	13460	12470	36.7	38.0	39.4
60	300	13040	12600	11680	34.3	35.6	36.9
70	290	12030	11620	10780	31.6	32.8	34.0
80	280	11100	10720	9930	29.2	30.2	31.4
90	270	10100	9740	9030	26.6	27.5	28.5
100	260	9150	8830	8200	24.1	24.9	25.9
110	250	8250	7970	7390	21.7	22.5	23.4
120	240	7475	7220	6680	19.7	20.4	21.1
130	230	6700	6460	5990	17.6	18.2	18.9
140	220	6110	5910	5470	16.1	16.7	17.4
150	210	5680	5490	5080	14.9	15.5	16.1
160	200	5330	5150	4770	14.0	14.5	15.1
170	190	5140	4960	4600	13.5	14.0	14.5
180		5060	4890	4530	13.3	13.8	14.3

TABLE 6 TURNING EFFORT OF NET PISTON FORCE

α Deg.	Net piston force, lb.	Component up con. rod, lb.	Moment arm, ft.	Turning effort, ft-lb.
0	285	285	0.0	0.0
10	290	289	0.050	14.45
20	262	261	0.100	26.10
30	200	198	0.140	27.70
40	143	140	0.176	24.64
50	105	102	0.202	20.60
60	70	68	0.222	15.10
80	30	28	0.228	6.38
90	22	21	0.220	4.62
100	15	15	0.205	3.08
120	5	5	0.164	0.82
140	1	1	0.115	0.11
160	−1	−1	0.057	−0.06
180	−30	−30	0.000	0.00
200	27	27	0.057	1.54
220	30	29	0.115	3.34
240	35	33	0.164	5.41
260	42	40	0.205	8.20
270	47	44	0.220	9.68
280	54	51	0.228	11.63
300	69	66	0.222	14.66
320	83	82	0.176	14.42
340	96	95	0.100	9.5
360	−102	−102	0.000	0.0
380	−100	−100	0.100	−10.00
400	−89	−88	0.176	−15.50
420	−75	−73	0.222	−16.20
440	−59	−58	0.228	−13.22
450	−50	−49	0.220	−10.78
460	−45	−44	0.205	−9.03
480	−40	−39	0.164	−6.40
500	−35	−35	0.115	−4.03
520	−32	−32	0.057	−1.82
540	−32	−32	0.000	0.00
560	32	32	0.057	1.82
580	32	32	0.115	3.68
600	33	32	0.164	5.25
620	36	35	0.205	7.18
630	37	36	0.220	7.92
640	39	38	0.228	8.66
660	39	38	0.222	8.43
680	26	26	0.176	4.57
700	−10	−10	0.100	−1.00
720	−75	−75	0.000	0.00

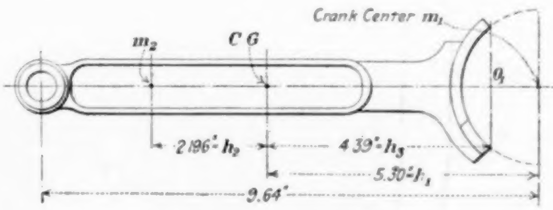

Fig. 9 Inner Connecting Rod

TABLE 7 TURNING EFFORT OF CONNECTING RODS

α Deg.		Inner Rod: Equivalent inertia, lb.	Inner Rod: Moment arm, ft.	Inner Rod: Turning effort, ft-lb.¹	Central Rod: Equivalent inertia, lb.	Central Rod: Moment arm, ft.	Central Rod: Turning effort, ft-lb.¹	Outer Rod: Equivalent inertia, lb.	Outer Rod: Moment arm, ft.	Outer Rod: Turning effort ft-lb.¹
0		43.2	0	0	44.7	0	0	46.5	0	0
10	350	42.8	0.078	3.34	44.4	0.076	3.38	46.0	0.073	3.36
20	340	42.0	0.141	5.92	43.4	0.140	6.08	45.1	0.135	6.09
30	330	40.5	0.213	8.64	42.0	0.208	8.74	43.6	0.204	8.90
40	320	38.8	0.271	10.52	40.2	0.265	10.65	41.8	0.260	10.87
50	310	36.7	0.313	11.50	38.0	0.307	11.68	39.4	0.302	11.90
60	300	34.3	0.351	12.04	35.6	0.346	12.30	36.9	0.338	12.47
70	290	31.6	0.372	11.75	32.8	0.366	12.00	34.0	0.355	12.08
80	280	29.2	0.380	11.10	30.2	0.372	11.24	31.4	0.362	11.37
90	270	26.6	0.384	10.20	27.5	0.375	10.30	28.5	0.364	10.38
100	260	24.1	0.369	8.90	24.9	0.363	9.05	25.9	0.348	9.03
110	250	21.7	0.344	7.46	22.5	0.336	7.56	23.4	0.320	7.49
120	240	19.7	0.318	6.26	20.4	0.307	6.26	21.1	0.293	6.18
130	230	17.6	0.281	4.95	18.2	0.273	4.97	18.9	0.258	4.88
140	220	16.1	0.237	3.82	16.7	0.230	3.84	17.3	0.218	2.77
150	210	14.9	0.185	2.76	15.5	0.180	2.78	16.1	0.167	2.69
160	200	14.0	0.129	1.81	14.5	0.127	1.84	15.1	0.117	1.77
170	190	13.5	0.068	0.92	14.0	0.065	0.91	14.5	0.060	0.87
180		13.3	0.000	0.00	13.8	0.000	0.00	14.3	0.000	0.00

¹ Turning effort is positive up to 180 deg. and negative from 180 to 360 deg. as shown in Fig. 10.

TABLE 8 TURNING EFFORT OF COMPOUND SUPPLEMENTARY INERTIA OF PISTON

α Deg.		Inertia, $2U\omega m$, lb.	Moment arm, S, ft.	Turning effort, ft-lb.[1]
0		0	1.033	0
10	350	105.5	1.027	108
20	340	206	1.011	208
30	330	295	0.983	291
40	320	371	0.952	353
50	310	428	0.912	390
60	300	469	0.870	408
70	290	489	0.824	404
80	280	491	0.780	382
90	270	474	0.738	350
100	260	445	0.700	311
110	250	401	0.667	267
120	240	352	0.640	225
130	230	296	0.616	182
140	220	237	0.599	142
150	210	178	0.588	105
160	200	118	0.580	68
170	190	59	0.575	34
180		0	0.574	0

[1] Turning effort is positive up to 180 deg. and negative from 180 to 360 deg. as shown in Fig. 4.

Turning Effort of Connecting Rods. The simplest way of now determining the turning effort caused by the inertia of the connecting rods is by the Kinetically Equivalent System Method.

A kinetically equivalent system is a group of bodies rigidly connected together which will be given the same acceleration as an actual link under the action of the same forces. To meet this requirement, three conditions must be fulfilled:

1 The two systems must have the same mass
2 The two systems must have the same center of gravity
3 The two systems must have the same moment of inertia.

The simplest kinetically equivalent system which can be substituted for the connecting rods is shown in Fig. 9. It consists of two heavy particles m_1 and m_2 connected by a weightless link. Then, to satisfy the conditions of equivalence:

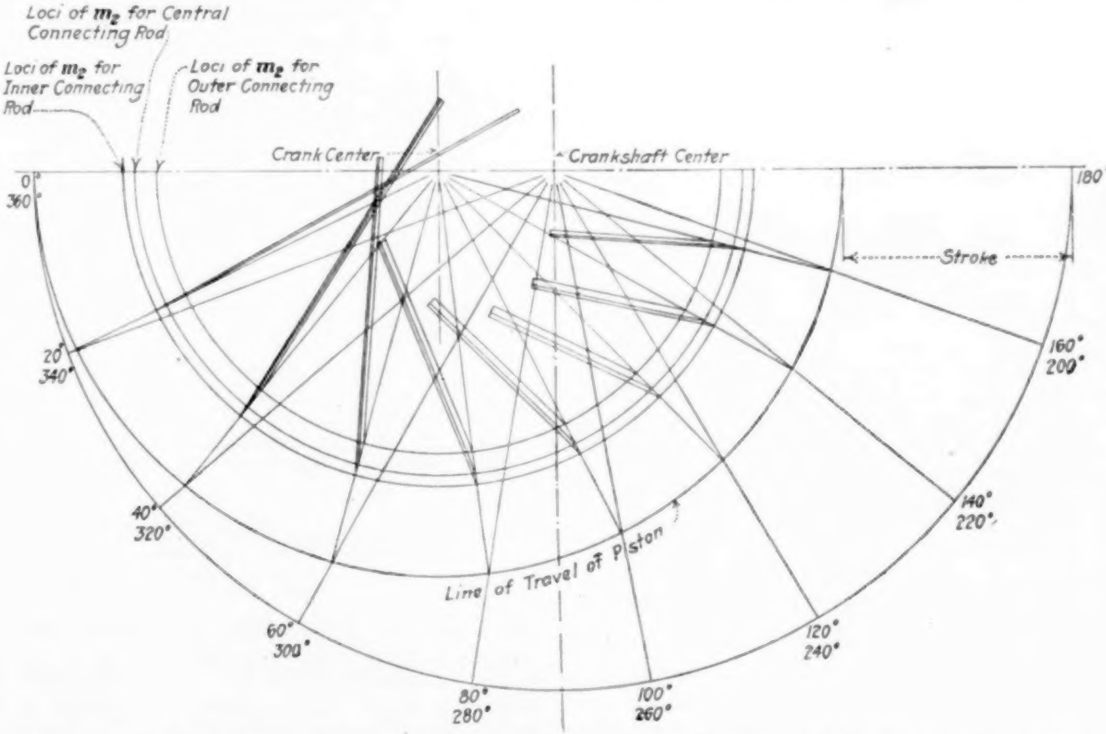

Fig. 10 Moment-Arm Diagram for Inertia Force of Kinetically Equivalent System of Connecting Rods

$m_1 + m_2 = m$ .... [4]

$m_1h_1 = m_2h_2$ .... [5]

$m_1h_1^2 + m_2h_2^2 = I = mk^2$ .... [6]

Eliminating the masses m_1, m_2 and m, Equation [6] reduces to $h_1h_2 = k^2$. Assuming any convenient value for h_1, h_2 can be found, thus locating the masses m_1 and m_2.

The mass m_1 is taken at the crank center so that it has no acceleration, and therefore it also has no inertia force. The mass m_2, its distance h_2 from the center of gravity of the connecting rod, and the inertia of the connecting rods can now be found. For the inner connecting rod—

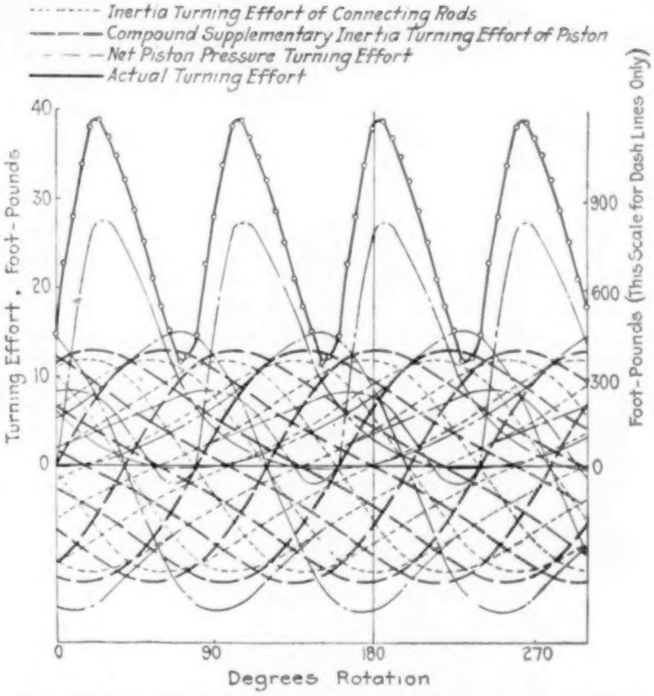

Fig. 11 Turning-Effort Diagram of LeRhone 80-Hp. Motor

$$h_1h_2 = k^2 \text{ and } h_2 = \frac{11.635}{5.3} = 2.196 \text{ in.}$$

Solving Equations [4] and [5] simultaneously:

$$m_1 + m_2 = 1.2$$

$$5.3^2m_1 + 2.196^2m_2 = 1.2 \times 11.635$$

$$m_2 = 0.848 \text{ lb.}$$

From Fig. 9, the acceleration of $m_2 = 0.778$ times the acceleration of the piston at any instant and lies in the same direction.

Similarly, for the central and outer rods $m_2 = 0.907$ lb. and 1.017 lb., respectively, and the corresponding accelerations of m_2 are 0.752 times and 0.697 times the acceleration of their pistons at any instant and lie in the same direction.

(Continued on page 654)

The Degasification of Boiler Feedwater

Fundamental Laws Governing the Separation of Dissolved Gases from Water by Air-Tension Control, and the Extent of Their Application to Conventional Types of Feedwater-Heating Equipment

By J. R. McDERMET,[1] JEANNETTE, PA.

DEAËRATION of the water fed to boilers and economizers for the prevention of corrosion is now a commercial realization. Engineering experience has also established empirically the degrees of degasification required, and indicated broadly the field in which it will be useful. One method among several which have met with success has been discussed from these relationships by the author in two previous papers,[2] and he proposes here to deal with the fundamental laws governing the operation of this method, and to indicate the extent of their application to conventional types of feedwater-heating equipment.

The method of degasifying water referred to above consists in first heating it to a temperature some 25 deg. fahr. above the temperature at which it is to be deäerated, this latter temperature being selected by reason of operating conditions. The heated

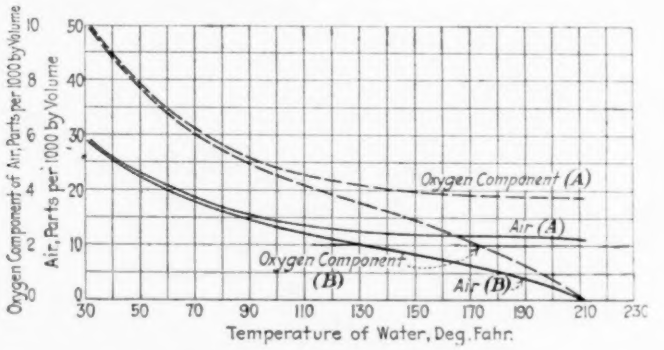

Fig. 1 Solubility Curves for Air in Water

[(A) Total pressure of air = 29.92 in. Hg.; (B) Partial pressure of air + pressure of water vapor = 29.92 in. Hg.]

water is then suddenly introduced into a chamber in which a vacuum is maintained by a condenser and an air exhauster in series. The vacuum is so correlated with the heater temperature that the water entering the deäerator chamber is superheated roughly 25 deg. above the temperature of the vacuum. This superheat energy produces a partial flashing into steam, and a pulverization of the liquid as it is suddenly injected. The steam, from the instantaneous boiling, enters the condenser, which is cooled by the supply water on its way to the heater. The heat liberated is recovered by the condenser and recirculated back to the heater. The non-condensable gases originally dissolved are removed from the end of the zone of condensation in the condenser by the air exhauster.

The process is significant in that it involves no heat losses. A small quantity of heat, amounting roughly to 25 B.t.u. per lb. of water handled, is continuously recirculated between deäerator and heater, and any degradation of form which it suffers is not significant in heating processes. There are, however, energy charges in removing the water from the region of vacuum and in exhausting the non-condensable gases from the condenser.

The successful operation of this process depends upon three factors: (*a*) The inevitable reduction of solubility of dissolved gases in water with increase of temperature. This advantage is common to all forms of water-heating apparatus; (*b*) the explosive boiling caused by the rapid injection of heated water into a zone of lower boiling temperature. While only a very small amount of heat energy is involved, the rate of energy liberation is quite rapid, producing a boiling action, which is independent of diffusion currents within the liquid and results in a very effective disruption of the liquid; (*c*) a method of control and agitation of the water subsequent to the explosive boiling in a region of reduced air tension. This reduction of air tension is secured partly by the reduction of total pressure incident to the vacuum, and partly by the control of the boiling process to furnish a partial vapor component of total pressure to reduce the partial air tension, the sum of the two being equal to the pressure in the region of vacuum. Factors (*b*) and (*c*) in their application are unique with this apparatus, but the control of air tension is significant in any process of aeration or deäeration. This factor of air tension is the criterion by which to judge the performance of other types of feedwater-heating apparatus from the standpoint of the removal of dissolved gases.

The solution of gases from the atmosphere, eliminating carbon dioxide which goes into chemical combination, follows Henry's law. The principal gases in air—oxygen, which produces corrosion, and nitrogen, which furnishes the bulk of the volume—have different solubility constants, and it is expedient, therefore, to consider the application of Henry's law to the individual constituents. Henry's law is formulated by Nernst[1] thus: "Gases dissolve in any selected solvent in the direct ratio of their pressures." When applied to a gaseous mixture this law may be made more specific by saying that the solubility of any constituent is equal to a proportionality factor, which is different for each permanent gas and itself a function of the temperature multiplied by the partial pressure of the constituent. At any constant temperature the solubility of any constituent for purposes of engineering calculation varies directly as the partial pressure.

The solubility curves for air in water presented in Fig. 1 have been recomputed from the solubility data of Winkler. Two

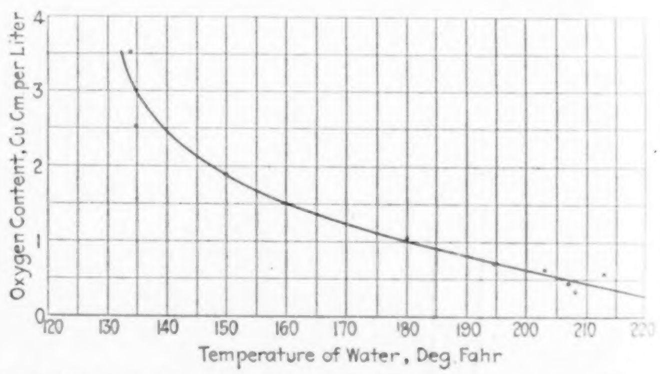

Fig. 2 Dissolved Oxygen in Water in Open-Type Feedwater Heater in Representative Central Stations

(Heaters fed with condensate from condensers.)

sets of curves are given, for both the oxygen component of air and for air, one set having been computed for a total pressure of air equal to 29.92 in. of mercury, and the other so that the sum of the partial pressure of the air and the pressure of the water vapor corresponding to the temperature will be 29.92 in. of mercury. Obviously, in the first case the total pressure is indeterminate without calculation, and in the second case the same is true of the partial air pressure. However, the two groups of curves are useful, for between their intercepted ordinates lie the solubility values of air in water for any open feedwater heater operating on raw water and under atmospheric pressure.

It is characteristic of an open-type feedwater heater that it operates under atmospheric pressure irrespective of the temperature to which it heats, and that the supplies of water and steam are not interrelated. As a result the control of partial air pressure in the heater depends primarily on the control of venting if the heater is

[1] Research Engr., Elliott Co. Mem. Am.Soc.M.E.

[2] Trans. Am.Soc. M.E., vol. 42, p. 267; and Mechanical Engineering, vol. 43, no. 5, p. 319.

Presented at a meeting of the Baltimore Section of The American Society of Mechanical Engineers, Baltimore, Md., April 12, 1922.

[1] W. Nernst, Theoretical Chemistry.

operated at a temperature close to the atmospheric boiling point. Invariably, there is a high air tension and a very considerable saturation if the heater is operated appreciably below the boiling point. Fig. 2 gives the results obtained from various types of such heaters fed with condensate from surface condensers. The data plotted were collected in a general survey of representative central stations scattered over an area east of the Mississippi River and are indicative of the average performance.

One point on this curve, however, is taken from a thoroughfare heater operating at 208 deg. fahr. This heater was installed in a blast-furnace boiler plant, and the entire exhaust of the blowing engine was discharged through the heater. This corresponded to a more extravagant venting than is permissible in standard practice, but it indicates decisively the results a heater may give under proper reduction in partial air tension. All of the other heaters operate with the minimum amounts of venting consistent with temperature desired and in accordance with usual central-station practice.

The results to be expected from any standard heater operating with raw-water feed are illustrated in Fig. 3. One point is significant in this curve—that for an Elliott 1000-hp. open heater—and, in general, is applicable to all types of open heaters. There is a viscosity-surface tension relationship in water which prevents the liberation of air bubbles at temperatures below 160 deg. fahr. As a result, unless considerable precaution is taken, the air-removal results for heaters operating below this temperature are very erratic and sometimes represent no separation at all. As temperatures rise above 160 deg. the solubility values more closely approach the theoretical, but in any event the equilibrium of solubility between gases and water is obtained very slowly, and accordingly, heater results even within this range are sometimes disconcerting. It is possible, however, to calculate, as in Fig. 4, the minimum solubility to be expected from an open heater. This calculation is primarily a proposition in air tension. It is very difficult, if not impossible, however, to get a heater which will equal this performance on saturated supply water, and the curve, therefore, is only of suggestive significance.

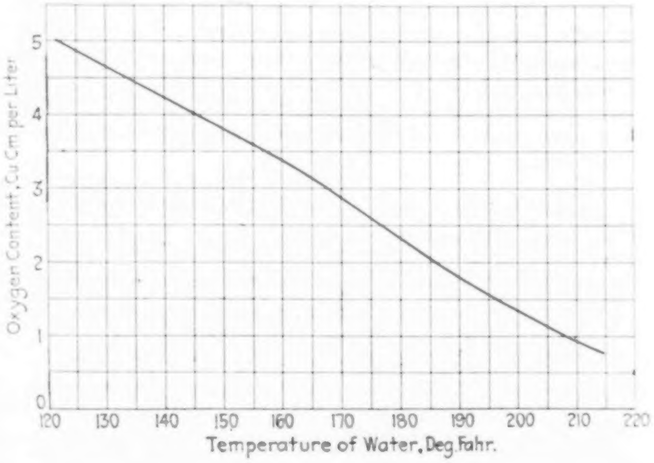

Fig. 3 Dissolved Oxygen in Water in Standard Heaters Operating with Raw-Water Feed
(Water saturated at 70 deg. fahr.)

The reason for the high values shown in the heater-performance curves is explainable from the curve of Fig. 5, which is plotted for vent mixtures from open feedwater heaters. It is an axiom in condensation work that the most efficient place for the removal of non-condensable gases is at the end of the zone of condensation. Unfortunately, there is no correlated control of steam and water in an open heater, and as a result no definite zone of condensation exists; it is therefore necessary to consider air removal on a pure vapor-mixture basis. As a result, in order to adequately remove a pound of air, it is necessary to remove a very significant amount of steam, even though the actual quantity of air involved is small. This curve rises so rapidly at 210 deg. as to make adequate venting almost prohibitive from a heat standpoint. It is primarily for this reason that open heaters do not adequately solve the deäeration problem.

A series of curves analogous to Fig. 5 but for a condenser heater of the jet type, are shown in Fig. 6. Since these heaters operate under vacuum and with different degrees of air exhaustion, the curves are plotted for different air tensions in the condenser body. The condition of control of steam and water exists under the same unfavorable circumstances as in the atmospheric heater, and air-removal conditions are extremely severe. Therefore, the three upper curves, for 0.2, 0.4 and 0.6 in. of mercury air tension, are of comparatively little significance, and the expense of pumping out the air mixtures has practically relegated the zone of operation to air tensions within the zone of the three lower curves, for 0.8, 1.0 and 1.2 in. of mercury air tension.

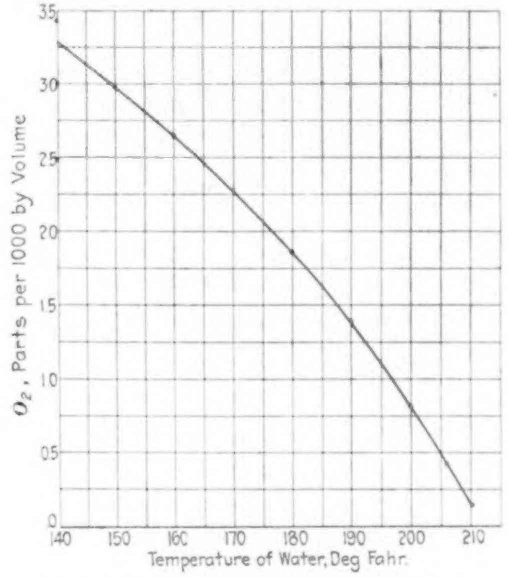

Fig. 4 Minimum Oxygen Saturation to be Expected with an Atmospheric Open Heater

In the open feedwater heater, venting is secured at the expense of steam only. In the jet-condenser heater, operating at vacuum, the vapor mixture must be mechanically exhausted. From a steam-ejector standpoint it requires practically as much energy to evacuate a pound of steam as it does a pound of air. Jet-condenser heaters have uniformly been more efficient äerators than deäerators, although their other merits are making their use extremely popular. In one installation, which perhaps may be said to represent the best from the standpoint of deäeration, the solubility of the water leaving the condenser is practically regulated by the condensate coming over from the main turbine condenser. In this case the jet condenser removes no air, but fortunately does not allow any to be added. It is also true that equilibrium between air and the solution of air in water is so slowly attained that spraying

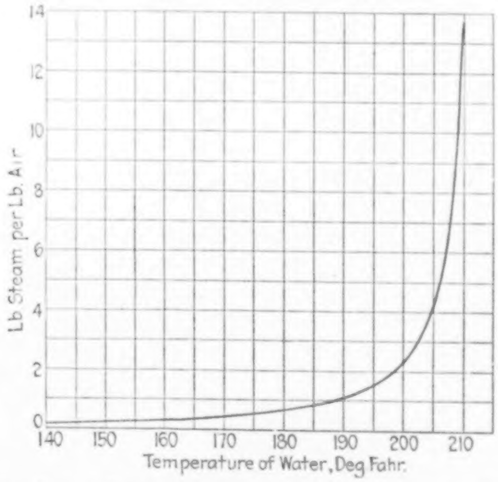

Fig. 5 Air-Steam Ratios in Venting Atmospheric Open Heaters

methods are uniformly unsuccessful in producing complete deäeration. There is, therefore, little probability that the jet-condenser heater, even with extravagant air-removal capacity, will offer a successful solution. It has, however, under the best conditions of heating, marked one step in advance, in that it has been

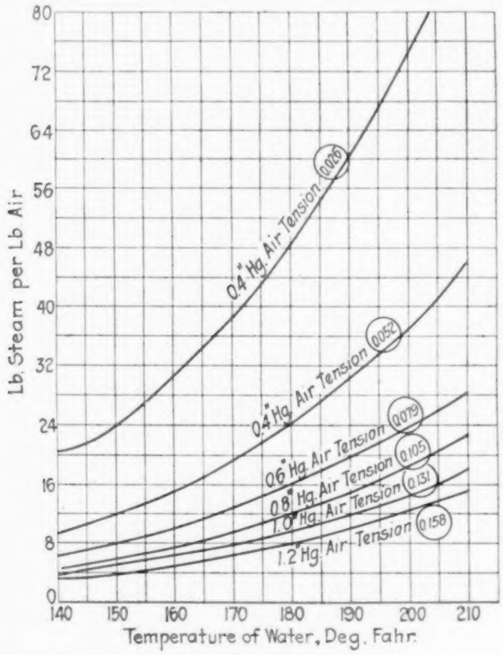

Fig. 6 Air-Steam Ratios in Removing Air from Jet-Condenser Heaters

(Figures in circles are mean solubility values in cubic centimeters per liter.)

found capable of preventing pollution of the water handled.

The use of surface-condensing apparatus has two inherent disadvantages. While the condensate or water which is to be heated does not come in contact with air, the use of such apparatus for exhaust steam from small turbines under modern boiler conditions

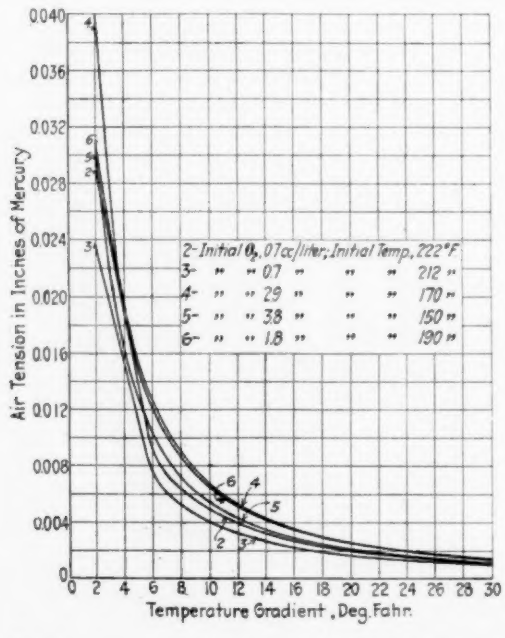

Fig. 7 Characteristic Curves of Deäerator Described in Text

is limited by the conductivity of superheated steam. The exhaust from small auxiliaries is so high in superheat under high boiler pressure and high boiler superheat that it is almost impossible to secure a workable conductivity without desuperheating. Where desuperheaters are employed or steam is extracted from an intermediate stage of the main unit within the saturated zone, the problem is complicated by the äeration of the condensate in the heater.

Fig. 7 indicates the analogous condition of control of air tension in the deäeration process previously described. The scale of ordinates for these curves is inches of mercury air tension, and the scale of abscissas the B.t.u. drop in the instantaneous boiling. The various curves range between the maximum and minimum operating temperatures employed in the process and for initial air contents which ordinarily accompany these temperatures in feedwater heaters of the open type. Obviously, the closed type merely retains the air content of the water entering it. It is a fortuitous circumstance that the natural coördination between normal air contents in heating apparatus and vacuum are such that these curves even for widely different conditions are approximately parallel and lie within the same zone. The minimum air tensions in the operating range amounting to less than 0.002 in. of mercury, indicate very forcibly the reason for the effective results which are secured by this process. However, the results which are theoretically obtainable are decidedly lower than the results actually obtained. The water is handled in the region of vacuum by agitating pans, which as a general premise are very much more effective than any type of spray nozzle. These curves are not in any sense an exposition of the complete operation of the deäeration process under consideration, but they do explain very satisfactorily and very accurately the underlying principles upon which successful operation is based, and indicate in radically new ways the relation of these principles to other features of power-plant apparatus.

Some mention was made in an earlier paragraph of the fact that a gradient of 25 deg. was employed between the heater and the deäerator. For all conditions of pressure the characteristic curves become practically parallel to the axis of abscissas in the neighborhood of 25 deg. There is no appreciable gain from increasing this value and it is economically wrong to extend the range of temperature gradient unless it be for some purpose of regulation as a part of a complete power plant. It is true, however, that the process does not operate efficiently at heater temperatures below 160 deg. fahr., and in case it is desired to go to operating temperatures on the deäerator as low as 130 deg. fahr., the temperature range must be extended beyond 25 deg., regardless of economic proportioning.

Vanadium metal is a silver-white lustrous metal with an atomic weight of 51.2 and a specific gravity of 5.5. It owes its great economic value to the fact that when added to steels in quantities ranging from 0.05 per cent to 0.50 per cent, it removes occluded oxygen and nitrogen, and combines with the steel to the very great improvement of its physical properties. In the smaller proportions, it confers great toughness to steel, making it particularly well adapted for automobile axles and other parts subject to excessive stress. In larger proportions it is used in high-speed and other tool steels to which it imparts certain desirable qualities which no other known substance can give in an equal degree. This fact has led to its becoming a standard constituent of such steels. Nearly all the vanadium in such steels is found in the pearlite as a combined carbide of vanadium, iron and any other metals present.

In English high-speed tool steels, the vanadium proportion is usually from 1 per cent to 1.5 per cent. Prior to the war, high-speed steels contained carbon, chromium, tungsten, and vanadium in varying proportions but the vanadium proportion was not more than 1.5 per cent. While these steels were excellent materials for high-speed tools, very much better steels have since been discovered, practically all of which contain vanadium. An interesting development has been the subject of a British patent in which the inventor claims that 18 per cent of tungsten can be replaced with advantage by 6 per cent of molybdenum in the presence of a little over 1 per cent of vanadium. In these steels vanadium is regarded as the key element, and its functions are described as stabilizing the variable properties of molybdenum steel and the prevention of cracking during the water-hardening operation. The result is said to be not only a steel of remarkable hardness but also thermal stability. Moreover, it is claimed that this molybdenum-vanadium steel does not "let down" until a heat of 700 deg. cent. is reached, in which respect it is superior to most other steels of this class.—*Engineering* (London), Aug. 4, 1922, p. 151.

An Investigation of the Herschel Type of Weir

Results of Tests Made to Determine the Effect of Various Modifications in Construction on the Action of the Improved Type of Weir Designed by Clemens Herschel for Gaging in Open Channels

By RICHARD H. MORRIS,[1] HARRISON, N. J., AND ALBERT J. R. HOUSTON,[2] BOSTON, MASS.

THE great multiplicity of weir types and the corresponding multiplicity of weir formulas early led Mr. Clemens Herschel to believe that the problem of measuring large quantities of water was being attacked from the wrong angle. As early as 1898, in an article in *Engineering News* for November 10 of that year, he protested against the usual method of making weir observations and suggested that the measurements be taken at the crest. When The American Society of Mechanical Engineers appointed a committee to draft a revised form of Power Test Code in 1917, Mr. Herschel was made a member and the Engineering Foundation made an appropriation to be expended by him in research work on weirs. In September, 1919, in the Hydraulic Laboratory of the Massachusetts Institute of Technology, he built and tested a weir which he briefly described in an article entitled An Improved Weir for Gaging in Open Channels, as follows:

> The fundamental idea followed in the design of the new weir was to have the water to be measured conducted over the weir in a gentle manner, and so as to have it flow smoothly and regularly from the time it first encounters the weir construction until it leaves it. Instead of allowing the body of water to impinge with more or less violence, according to the velocity with which it approaches the weir, against a perpendicular wall in its path (the upstream face of the ordinary weir), it is gently led to the crest by a 2:1 slope. Instead of striking on or being torn over a sharp edge at the crest, the crest is made in the form of an arc of a circle; and instead of bothering about air under the nappe, the nappe is supported on another 2:1 slope downstream from the crest. Moreover, the crest is made hollow so that observations of the pressure or lack of full pressure, whichever the water may elect to exercise, can be taken at the crest, not at a distance upstream from the crest at a distance varying according to the fancy of the experimenter.
>
> If the quantity passing over the weir turn out to be a function of this observed pressure, well and good. If not, we will see what virtue there is in the difference of water elevations or pressures, the one taken upstream from the weir and the other taken by means of the hollow weir crest.

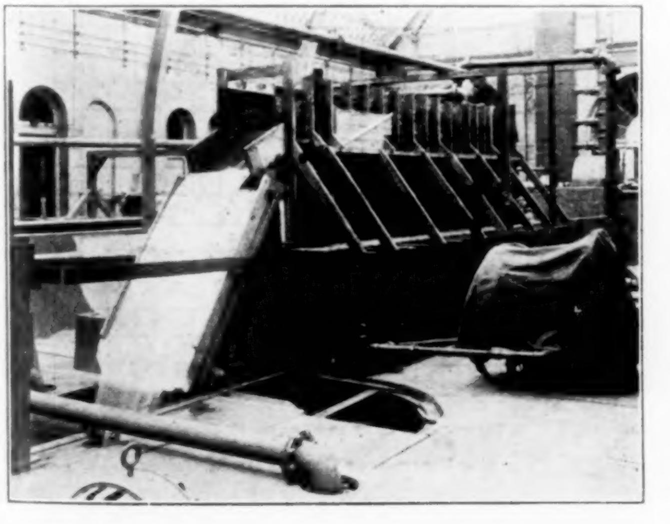

Fig. 1 Herschel-Type Weir as Arranged for Testing

> The difference referred to above proved to be the sought-for solution of the problem at hand...... A United States patent has been applied for covering the weir construction herein described.
>
> Our weir crest had a radius of 0.198 ft., and the outside surface was hard and smooth oil paint.

The results of this test were presented to The American Society of Mechanical Engineers at their Spring Meeting in May, 1920, an abstract of the paper having been published in MECHANICAL ENGINEERING for February of the same year. Mr. Herschel's tests showed that for discharges of from 0 to 9.55 cu. ft. per sec. per ft. of weir length (the limits covered by the experiments) the quantity of water flowing, Q, was directly proportional to the difference, d, in two pressures, one measured just upstream from the weir, and the other measured at the crest, the formula being $Q = 5.50\ d$.

Nature of the Investigation Undertaken

The work herein described constitutes an investigation of a Herschel-type weir from six distinct points of view. First, an attempt was made to check the work of Mr. Herschel. Next, it was desired to find the effect on the action of the weir of the following five modifications in its construction:

1 The degree of smoothness of the crest and slopes
2 The radius of the crest
3 The position at which the upstream measurement is made

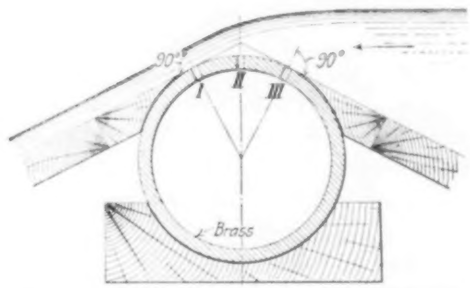

Fig. 2 Detail of Crest of Herschel-Type Weir

4 Increasing or decreasing the velocity of approach
5 Changing the position of the orifices in the crest.

Undeniably, the work should have included an investigation of the effect of different slopes. However, neither time nor funds were available for such extensive work as this would require.

Definitions of Terms

Throughout this paper whenever any of the following terms are used their meaning will be covered by the definitions here given.

Crest: The brass tube set at the juncture of the two slopes, forming a smooth, slightly curved surface over which the water flows.

Weir Length: The length of the crest at right angles to the direction of flow.

Velocity of Approach: The mean forward velocity of the water in the section of the weir box at the foot of the upstream slope, computed by the formula $V = Q/A$.

Sharp-Crested Weir: The ordinary type of weir in which the crest and sides are made of a thin slab of metal so constructed that the nappe or overfalling water touches only the sharp upstream corner or edge of the crest.

The Apparatus Used

The tests to be described were performed in the Hydraulic Laboratory of the University of California. Among other things this laboratory is equipped with six electrically driven centrifugal pumps, two calibrated measuring tanks, and two storage tanks. A sharp-crested weir is arranged to overflow into one of the calibrated tanks. The Herschel-type weir to be tested was built on top of the sharp-crested weir. All six of the pumps were arranged to discharge into the new weir. From it the water ran into one of the calibrated tanks, which in turn overflowed into the other calibrated tank. By means of a sliding gate the water could be diverted from the calibrated tanks into one of the storage tanks without stopping the pumps. The combined capacity of the six

[1] Worthington Pump & Machinery Corp. Jun. Mem. Am.Soc.M.E.
[2] 44 The Fenway. Jun. Mem. Am.Soc.M.E.
Abridgment of paper awarded the A.S.M.E. Student Prize for 1921.

pumps was approximately seven and one-half cubic feet of water per second.

In external appearances, as shown in Fig. 1, the new weir very much resembles a long, narrow box with its sides braced on the outside. The box was $17^1/_2$ ft. long, 5 ft. high, and a little over 2 ft. wide. The crest was 2.0335 ft. long and was made of a brass pipe with a line of $^1/_8$-in. holes along its length, spaced 1 in. apart.

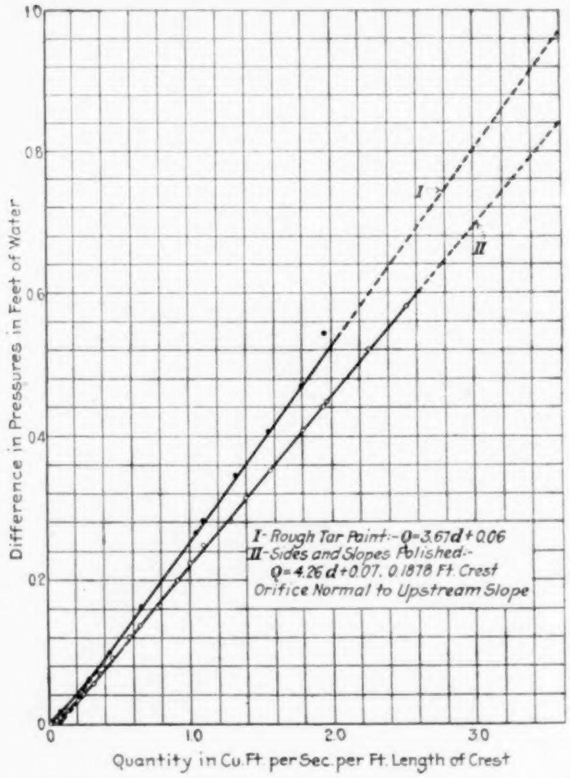

Fig. 3 Effect of Roughness of Surfaces on Discharge of Herschel-Type Weir

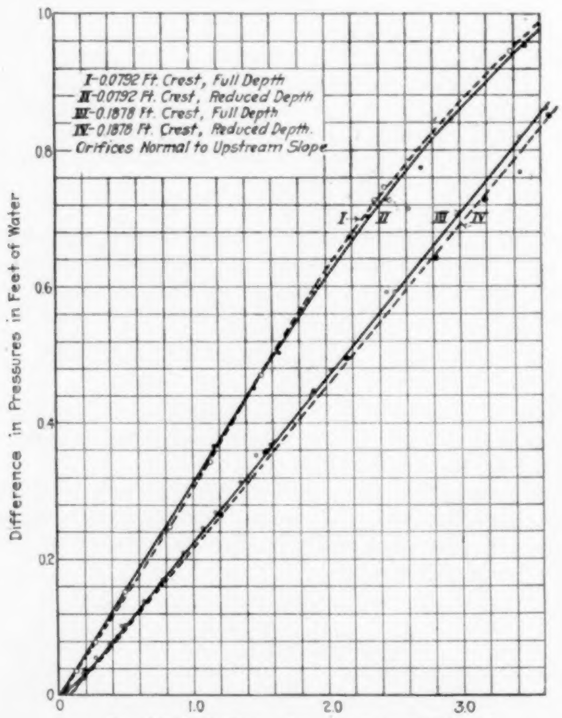

Fig. 4 Effect of Radius of Crest and Velocity of Approach on a Herschel-type Weir

Two different sizes of pipe were tried, one being a standard 4-in. pipe and the other about 2 in. in diameter. The actual external radii of these pipes were 0.1878 ft. and 0.0792 ft., respectively. The crest was placed 3 ft. above the floor of the weir. The approach to and from the crest had a slope of 2:1, that is, 1 ft. rise for each 2 ft. horizontal distance. The whole construction, except the pipe, was of wood, the supporting timbers being 4 in. by 4 in., the braces 2 in. by 4 in., and the sides, floor and slope $^7/_8$-in. tongued and grooved flooring. The weir was fitted with three orifices for measuring the upstream pressure. These were flush with the side, $^3/_4$ ft. below the level of the crest, and respectively 6 ft., $7^1/_4$ ft., and $8^1/_2$ ft. upstream from the crest. From these orifices rubber tubing led to a water manometer constructed on an angle as is the conventional draft gage. The angle at which the manometer was set was such that 3 ft. along the slope corresponded to 1 ft. rise vertically. It was calibrated by comparison with a vertical gage. The pressure from the crest was also led to this same manometer, where suitably arranged valves made it possible to read the pressure at any of the three orifices or the crest. Baffle plates were used to steady the flow.

In order to increase the velocity of approach a raised floor or false bottom was sometimes set in the weir. It was 2 ft. above the original floor and terminated $9^1/_2$ ft. upstream from the crest in a 1:1 slope.

Laboratory Procedure

At first the 4-in. pipe was fitted with the $^1/_8$-in. orifices at right angles or normal to the upstream slope (position III, Fig. 2). A preliminary test of ten runs was made with the sides and slopes covered with rough asphaltum paint. The small cracks between the wooden slopes and the brass pipe were left open.

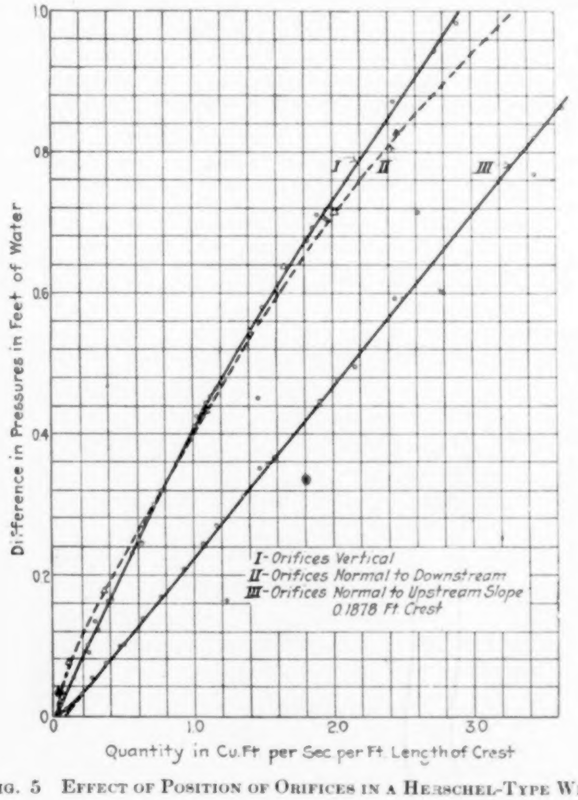

Fig. 5 Effect of Position of Orifices in a Herschel-Type Weir

These cracks were then filled and smoothed with modeling clay and the sides and slopes were scraped, oiled and polished. Another test of twenty-three runs was then made.

After completion of these tests the orifices in the crest were changed to the vertical position (II) and thirty-five more runs taken. A test of thirteen runs was then taken with the orifices at right angles to the downstream slope (position I, Fig. 2). It was found that pressure conditions were too unsteady with the orifices in positions I and II, so they were changed back to position III and a further test of twenty-five runs was then made. The

velocity of approach was next increased by fitting in the weir the raised floor and nine runs made.

With this raised floor still in place, the large pipe in the crest was replaced by the small one and the orifices set at right angles to the upstream slope. A test of ten runs was made with these conditions. The raised floor was then removed and eleven runs made.

The work of constructing the weir was begun on June 3, 1920, the first run was made on the 28th of the same month, and the last run was finished on July 23. The data obtained in the tests are given in an appendix to the complete paper.

The typical procedure in taking a run was as follows: The sliding gate was set so as to divert the stream of water into one of the storage tanks. Whatever pumps it was desired to use were then started and the throttle valves regulated to give the desired reading on the differential gage. The hook gages on the measuring tanks were then read. After the flow became steady the sliding gate was pushed under the stream so as to allow it to flow into the measuring tanks. The stop watch was started just as the gate moved under the stream. Readings were taken on the differential gage of the pressure both at the crest and at each of the three upstream orifices. Usually there was time to take several sets of readings and the mean of each was used in calculating the results. When the tanks were sufficiently full the sliding gate was pulled back into its first position so as to again divert the water into the storage tank, and the watch was stopped. Hook-gage readings were then taken of the water level in the measuring tanks.

It was found that if this weir was treated as an ordinary broadcrested weir of irregular section and the quantity discharged plotted on logarithmic coördinate paper against the upstream reading, the result was a very good straight line. Therefore the measuring tanks were not always used, but instead sometimes the quantity discharged was read off this logarithmic calibration curve.

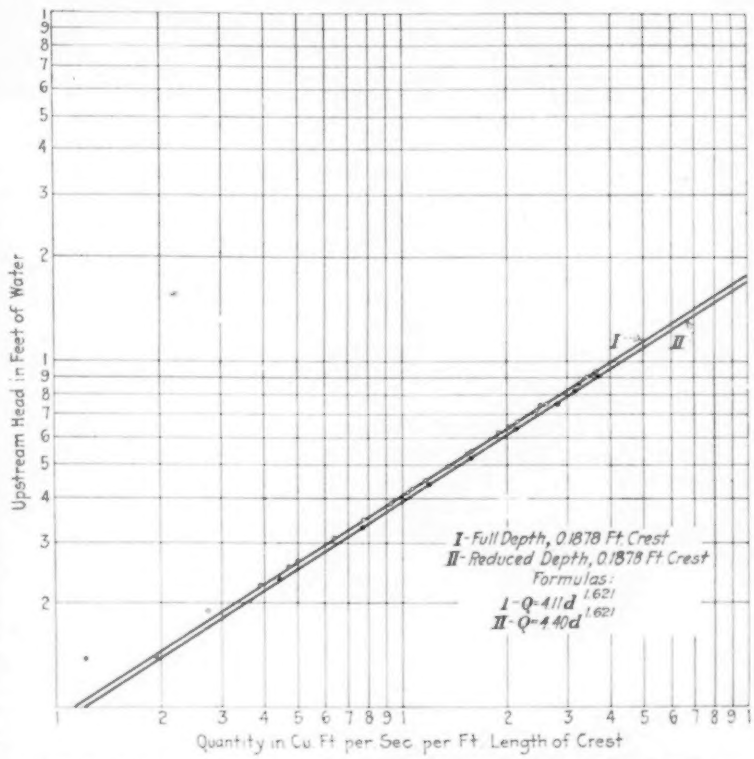

Fig. 7 Effect of Velocity of Approach on a Herschel-Type Weir
(For 0.0792 ft. crest, Q(full depth) = $4.3d^{1.621}$; Q(reduced depth) = $4.5d^{1.623}$.)

Calculation of Results

Curves were plotted of head due to velocity against quantity for both the full depth and the raised floor. It was then unnecessary to figure out the velocity head for each run. Instead it was merely read off the curve from the corresponding quantity. The following is a sample of the computations made for the full-depth curve:

$$\text{Quantity} = \text{Area} \times \text{Velocity, or } V = Q/A$$
$$\text{Velocity Head} = h_v = V^2/2g$$

where g is the gravitational constant. Q is measured in cubic feet per second per foot of length of crest. Then the area per foot of length of crest equals the height of the crest above the bottom of the weir plus the observed measured head upstream.

From the logarithmic calibration curve of the weir with full depth a quantity of 3.00 cu. ft. per sec. per ft. of length of crest corresponds to an upstream head of 0.810 ft. The crest is 3.015 ft. above the floor. Therefore the area per foot of length of crest is 3.015 + 0.810 = 3.825 sq. ft. Then—

$$V = Q/A = 3.00/3.825 = 0.785 \text{ ft. per sec.}$$
$$h_v = V^2/2g = (0.785)^2/2g = 0.615/64.36 = 0.00956 \text{ ft.}$$

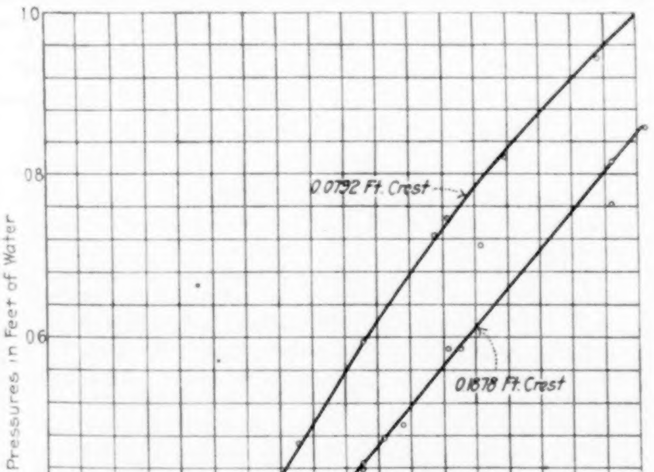

Fig. 6 Rating Curves of Herschel-Type Weir

Summary of Results

In plotting the accompanying curves from the data obtained the two following rules were always used: (1) $V^2/2g$ was always added to the difference between the crest and upstream pressures. (2) When a curve did not pass through the origin on rectangular coördinate paper, the value of the quantity where the curve cut the line of zero difference was subtracted from each quantity when plotted on logarithmic paper, giving an equation of the form $(Q-K) = Cd^n$.

From an examination of the curves it is evident that all the factors mentioned earlier in the paper affect the discharge to some extent. The discharge constant varies over a wide range, depending upon the existing conditions.

Friction greatly affects the discharge of this type of weir and, as is shown in Fig. 3, this variation may be as great as 12 per cent. This is a disadvantage and will have a bearing upon the change of slope, the effect being proportional to some function of the velocity—probably the square. Friction and contraction are the two limiting factors of the discharge, and from Bazin's experiments it seems that a 2:1 slope represents the point where the combined effect is about a minimum and the discharge a maximum. In order to offer a basis of comparison, it would be well if future experi-

menters would do their work with surfaces that are capable of fairly accurate reproduction, such as cement, hardwood flooring or germanstone.

Figs. 4, 6 and 8 indicate that the formula for the discharge is materially affected by the size of the pipe forming the crest. This may be explained in several ways. Generally speaking, by decreasing the radius of the crest a sharp-crested weir is approached, and the smoothness of flow is thereby altered. Thus the size of the crest affects the contraction and consequently the actual discharge. On the other hand, it will be seen that the size of the crest affects the crest gage reading and therefore the formula for the weir. For, since the holes are normal to the upstream slope, the size of the crest determines the distance from the top of the crest to the orifices. Therefore the size of the crest will vary the component of the velocity that enters the orifices. It is not known, however, whether these two effects tend to increase or oppose each other.

The particular curves (Figs. 6 and 8) of the small crest seem to indicate that each size of crest has definite limits between which the discharge varies as a straight-line function.

Upstream measurements taken with three gages were identical below about $3^1/_2$ cu. ft. per sec. per ft. length of crest. Above that quantity the gage nearest the crest showed a slight drop, indicating

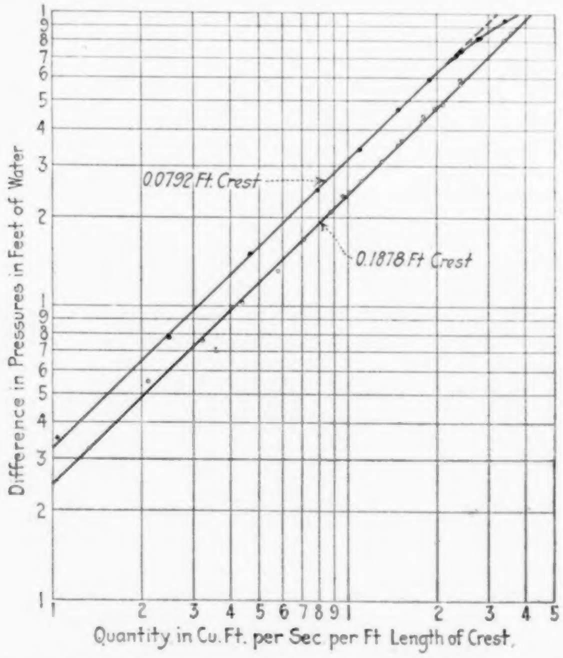

Fig. 8 Logarithmic Rating Curves of a Herschel-Type Weir
(For 0.1878 ft. crest, $Q = 4.16d + 0.07$.)

that the upper-surface curve extended at least 6 ft. upstream from the crest.

That the velocity of approach cannot be corrected for by means of the simple formula $V^2/2g$ is shown in Figs. 4 and 7. The velocity of approach was increased nearly 300 per cent, with a corresponding difference of about 7 per cent in the corrected discharge curves. The weir is therefore similar to a sharp-crested weir in this respect, because both Bazin and Francis specify that the height of the crest above the floor of the weir box must fall within certain limits if their formulas are to be applicable.

The most important factor is the position of the orifices in the crest as shown by Fig. 5. The discharge is a straight line-function only when the holes are normal to the upstream slope, or nearly so. The constant may be varied almost at will by rotating the orifices with respect to the horizontal axis of the crest. It is doubtful, however, if the constant 5.50 as obtained by Mr. Herschel could have been obtained with the weir used in these experiments, due to the difference of about 0.01 ft. in the crest radii.

Conclusion

The results of this investigation tend to show that when a weir of the Herschel type is properly constructed there is a constant ratio between the quantity of water passing over the weir and the difference in the two observed pressures. However, so many are the determinant factors and so great is their influence upon the discharge formula that a weir of this type, in its present state of development, would probably be valueless unless calibrated by actual tests. It is believed that further extended research may remedy this difficulty. Probably the chief advantage of the new weir lies in the fact that for the same upstream head it discharges about 20 per cent more water than the ordinary type of weir.

FORCES IN ROTARY MOTORS

(Continued from page 647)

Table 5 gives the accelerations and inertia forces of these equivalent masses for every 10 deg. rotation of the motor.

Plotting the net component piston force acting up the connecting rod for every 10 deg. rotation of the motor, and drawing its moment arm, the turning effort of the net piston force is calculated, the results for 20-deg. intervals being presented in Table 6. The maximum turning effort from this source for one piston is 27.7 ft-lb. and occurs when the cylinder is 30 deg. off dead center at the beginning of the stroke.

In Fig. 10 the direction of the equivalent inertia force of the connecting rods, for every 10 deg. rotation of the motor, is plotted and the moment arm shown. From this diagram the turning effort of the connecting rods is calculated and the results are given in Table 7. The turning effort is positive up to 180 deg. and negative from 180 to 360 deg. These positive and negative turning efforts exactly balance each other, the maximum occurring 60 deg. off dead center and amounting to about 12.5 ft-lb. per connecting rod.

Table 8 gives the turning effort due to the compound supplementary inertia force of the piston, $2U\omega m$ (heretofore neglected in similar calculations); which amounts to almost fifteen times that of the net piston force, and over thirty times that due to the inertia of the connecting rods. This is also positive up to 180 deg. and negative from 180 to 360 deg., the negative balancing the positive.

Fig. 11 shows a representative portion of the final turning-effort diagram of the LeRhone 80-hp. motor. The dotted lines represent the turning effort due to the inertia of the connecting rods; the dot-and-dash lines the turning effort due to the net piston pressure; the dash lines the turning effort due to the compound supplementary inertia of the piston; while the heavy lines represent the combined turning efforts. The inertia forces balance, and the final turning effort depends only upon the net piston pressure.

The "heat pump" is an apparatus working on a reversed heat-engine cycle, the object of which is to economize heat in evaporating processes, such as the concentration or the distillation of liquids.

In the heat-pump process the vapor from the evaporator is taken to a compressor, in which its pressure, and hence also its temperature, are raised to such a degree that the compressed vapor may serve as the heating medium in the evaporator. It is returned to the heating element of the evaporator accordingly, where it is used for the evaporation of a further amount of liquid.

While in certain circumstances a small quantity of live steam may have to be supplied, in general the only energy required in order to carry on the process is that necessary to drive the compressor. The efficiency of the process from the thermal or energy point of view may therefore be measured by comparing the evaporative effect produced with the power expended in driving the compressor. This power may be derived from fuel consumed in the power unit or station from which the compressor is driven, or, of course, from any other source of power, such as water power, and involve no expenditure of fuel at all. Also the compressor may be driven directly by the prime mover or the drive may be indirect, the transmission being effected electrically. The compressor may also take the form of a jet pump supplied from an external source with steam which mixes with the vapor from the evaporator, and is delivered with it to the heating element. The variations of the process are numerous, but all are characterized by the fact that the vapor produced is compressed and returned to the evaporator as the heating medium. T. B. Morley in *The Engineer* (London), July 14, 1922, p. 27.

The Fuel Problems of the Pacific Coast

The Future Fuel Supply of California—Reasons Why the Railways and Merchant Marine Should Receive Preferential Treatment in Case Oil-Fuel Conservation Becomes Necessary

AT A MEETING of the San Francisco Local Section of the A.S.M.E., held February 23, 1922, three papers were presented dealing with the conservation of the present fuel supply of the Pacific Coast and the development of new sources. Reasons were given why the railways and merchant marine of the Pacific Coast should not be affected by any restrictions in the use of fuel oil which the diminishing supply might make necessary. Abridgments of these three papers follow, together with the introduction to the discussion given by F. H. Sibley, dean of the College of Engineering, University of Nevada.

THE FUTURE FUEL SUPPLY OF CALIFORNIA

By C. H. Delany,[1] San Francisco, Cal.

IT IS the purpose of this paper to point out certain facts in connection with the future fuel supply of California which appear to be of importance in view of the possible decrease in available supply of California oil.

A recent joint survey, made by the United States Geological Survey and the American Association of Petroleum Geologists, estimates that the quantity of oil recoverable by present methods remaining in the ground in California on January 1, 1922, including known and probable fields, amounts to 1,850,000,000 bbl. For some years the production of oil in California has been in excess of 100,000,000 bbl. per year, so that it appears that if the present rate of production could be continued, the oil supply would be exhausted in less than twenty years. The estimate represents the best judgment of the geologists, but unknown fields may be discovered in the future, so that it is impossible to predict with any degree of certainty how long the oil supply will last.

While it is true the development of new oil fields in the state may increase the total supply of oil, it is also probable the development of methods of oil refining will in the future use more and more of the oil for gasoline and other valuable products and leave less and less for fuel purposes. It is also probable that the many advantages of oil for marine purposes will tend sooner or later to cut off the supply for many uses for which fuel is required on land. It therefore seems appropriate at this time to discuss the situation in which we will some day find ourselves when our present fuel supply is cut off.

The production of California oil, as shown by the records of the State Mining Bureau, has increased from 4,329,950 bbl. in 1900 to 114,800,000 bbl. in 1921. About 8 per cent of this is used as fuel in the oil industry itself, and over 80 per cent of the remainder is distributed as fuel to the industries of California and other states.

Table 1 shows the purposes for which oil was used as fuel in California during the year 1917. It is seen from this table that in that year the quantity of oil used as fuel in California amounted to 4,467,000 bbl. per month, or at the rate of 53,604,000 bbl. per year. On the basis of $3^1/_2$ bbl. of oil to one ton of coal, this quantity of oil is equivalent to 15,300,000 tons of coal. In addition there were used in 1917 in California over 700,000 tons of coal, bringing the total annual fuel requirements of the state up to an equivalent of 16,000,000 tons of coal. The population of California in 1917 was somewhat over 3,000,000, so the fuel requirements amount to about 5 tons of coal per capita. This compares with an average coal consumption throughout the United States for the year 1920 of 5.7 tons per capita. It is evident, therefore, that if the growth of California is to continue at the present rate, producing a population of 10,000,000 by 1950, and if the supply of California oil is cut off, we shall require by that time for fuel purposes the equivalent of 50,000,000 tons of coal per year.

TABLE 1 FUEL OIL USED IN CALIFORNIA
(Crude and residuum)

	Bbl. per Month	Per Cent
Railways	1,956,000	43.8
Steamships	555,000	12.4
Public utilities	555,000	14.7
Mining and smelting	52,000	1.2
Industries	483,000	10.8
Lime and cement	158,000	3.5
Sugar refining	103,000	2.3
Agriculture	73,000	1.6
Heating buildings	150,000	3.4
Miscellaneous	282,000	5.3
Total	4,467,000	100.0

Hand in hand with the development of the oil industry has gone the development of the hydroelectric-power industry, which is of course also responsible in a large part for the development and growth of California during the last twenty years. There is an impression among many that hydroelectric power will serve as a substitute for fuel and that when our oil supply has been used up we shall simply have to turn to the "white coal" of the Sierra Nevada Mountains.

There are many industries, however, that cannot do without fuel of some form, regardless of the quantity of electric power available. Of the 655,000 bbl. of oil used per month by public utilities, probably at least one-half was used for the manufacture of gas. Gas is a direct product of the oil itself, and if oil is no longer available some other fuel must be substituted for it. Lime and cement works used 158,000 bbl. per month. Electric power is already used extensively in these industries for operating the machinery, but fuel of some sort must be used in the kilns themselves. Heating by electricity is a possibility, but electric energy is of far greater value for the production of power than for the production of heat, and it is certain that the heating of buildings and industries requiring heat such as fruit canning, sugar refining, etc., will continue to demand an adequate supply of fuel.

Even if it were practicable to substitute electric power for all of the industries which are now using fuel oil, it must be borne in mind that there is a limit to the quantity of hydroelectric power available. It has been estimated that at the present rate of growth of the hydroelectric-power industries, the economic limit of hydroelectric development in the State of California will be reached in the year 1941. This limit, of course, will be reached all the sooner if hydroelectric power is substituted for fuel oil wherever practicable, such as by electrifying the railroads and the greater use of electric power in industry.

The question, therefore, is what kind of fuel is to be used after the California oil is exhausted, and where it is to come from? At first thought it would appear that fuel oil may be imported from other countries. However, on investigation we find that the petroleum supply of the whole world is quite questionable and cannot be depended upon to last more than 20 or 30 years, and as California would be in competition with the rest of the world in its use, we cannot count on a supply of imported oil that would meet our requirements. Natural gas is available in certain sections of California, but its use is only local in these particular sections, and it cannot be considered as a fuel supply for the whole state; moreover it is probable that the natural-gas supply will be exhausted sooner than the oil supply.

We must therefore turn to coal as the only reliable fuel for the future, and the problem accordingly becomes a question of where can we obtain our required supply of coal at the least expense and in a manner best suited to our own development.

A very complete survey of the coal resources of the world was made by the International Geological Congress held in Canada in 1913. From this report the information in Table 2 has been selected, applying to the Pacific Coast and neighboring states.

California coal is low-grade lignite, running from 9,000 to 12,000 B.t.u. per lb. Owing to the small quantity available it need not be given serious consideration as a substitute for fuel oil.

Oregon has a considerable supply of coal in Coos Bay region, much of which has been sent to California in former years, although

[1] Pacific Gas & Elec. Co. Mem. Am.Soc.M.E.

the output from the Oregon mines has always been small. Oregon coal is a very low-grade lignite, high in ash and moisture and running from 7,000 to 10,000 B.t.u. Owing to its low grade it would not be a satisfactory source of supply of fuel for power purposes although it has met with favor when used for domestic purposes.

The state of Washington has available large quantities of coal of a variety of grades. Bituminous coal is mined extensively and is of fair quality. Large deposits are found to the west of the Cascade Mountains, within 50 miles of Puget Sound, so that shipment by water to San Francisco and other California ports can be readily effected. Sub-bituminous coal or lignite, is found extensively within a few miles of Puget Sound, but this coal is of very low grade, contains a large amount of moisture and volatile matter, and disintegrates when exposed to the air so that it cannot be transported without losing much of its heating value.

TABLE 2 COAL RESOURCES OF PACIFIC-COAST AND NEIGHBORING STATES

	Area, Sq. Miles		Estimate of Original Amount of Coal in Million Metric Tons	
	Known coal fields	Possible coal fields	Low-grade lignite or sub-bituminous	Fair-grade bituminous
California	10	30	15	25
Oregon	90	140	907	....
Washington	1800	....	47588	10355
Idaho	230	1000	90	344
Nevada	....	....	....	....
Utah	3646	....	141	3630
Arizona	3610	....	12832	9
New Mexico	13220	....	156903	17173

Nearly 80 per cent of the coal now used in California comes from Utah, which state has a large supply of a fairly good grade of bituminous coal running from 12,500 to 13,000 B.t.u. per lb. However, owing to the distance and the high freight rate for rail transportation, amounting at present to over $7 per ton, this can never be a cheap coal on the Pacific Coast. In 1918 the total quantity of coal consumed in California amounted to 830,368 tons, of which 653,766 tons or nearly 80 per cent came from Utah.

New Mexico has abundant reserves of coal. Some of this coal now finds its way into California, but as it is a poorer grade than the Utah coal and must absorb as high a freight rate, it is not likely to become a serious factor in the fuel supply for California.

Practically no coal is now mined in Arizona, Nevada or Idaho. The coal fields of Arizona are located in the eastern part of the state and are at present inaccessible. The coal is of poor quality, having ash content in some cases as high as 50 per cent, and while it may eventually prove of value for local use it is not worth shipping to the coast. Nevada has only one known coal field, of small extent located in the central part of the state. Idaho contains three known coal fields, but the seams are thin, the coal is of an inferior quality and little development work has been done.

The most promising supply of high-grade coal for the Pacific Coast is in the territory of Alaska. The Pacific Coast section, which is in the southern part of the territory bordering on the Gulf of Alaska, contains 458 square miles of known coal fields and over 8000 square miles of possible coal fields. The coal available is of all characters, from low-grade lignite to the highest grade semi-bituminous and anthracite. An estimate of the quantity available is given in Table 3.

TABLE 3 COAL AVAILABLE IN THE PACIFIC COAST SECTION OF ALASKA

	Estimated amount of coal, million metric tons
Lignite	1971
Sub-bituminous	485
Bituminous	2
Semi-bituminous	1293
Anthracite	1931
Total	5682

The best grade of coal for steaming purposes is found in the Matanuska field, which is not far from the coast and through which the recently completed Government railroad passes. No coal has as yet been exported from Alaska, but it is probable that this will eventually become one of the main sources of coal for the Pacific Coast, especially for such purposes as require the higher grades of coal.

Turning now to the possibility of importing coal from foreign countries, we find that the nearest foreign coal available is that on Vancouver Island. Much of this coal has been imported into California in the past from the well-known Wellington Mine. This is a fair grade of bituminous coal running from 12,500 to 13,000 B.t.u. The quantity of coal available is estimated at 5,191,000,000 tons. Large reserves of coal are also found on the mainland of British Columbia.

Turning to South America, we find a good grade of bituminous coal located in Chile. This coal is near the coast and could readily be shipped. There is also in Chile some anthracite coal of excellent quality. The quantity of coal available is estimated at 2,000,000,000 tons. The best coal is found in the neighborhood of Santa Maria Island and contains only 4 or 5 per cent of moisture and from 2 to 11 per cent of ash. It burns with a long, smoky flame and contains over 13,000 B.t.u. per lb.

In Peru there is also an abundant supply of coal, although very little is mined at the present time. The reserve is estimated at 1000 million tons of commercial coal.

With the present development of commerce with the countries so far considered, if large importations of coal were made there would be no return cargo for the ships carrying it. In other words, unless commerce can be developed to such a point as to bring about a considerable export trade from California to Chile or Alaska, as the case may be, the cost of transportation of coal would be doubled by the necessity of sending the ships back in ballast. It is thus evident that the question of future coal supply for California is intimately associated with the development of California's export trade. This leads us to consider the possibility of importing coal from countries at greater distance, with which trade is most likely to develop. Previous to the development of the California oil industry coal was imported from Australia, Japan, England, Wales and Scotland, as well as from British Columbia.

Some of the world's greatest coal deposits are found in China. It is estimated that China contains 999,000 million tons of high-grade coal, amounting to about one-fifth of the world's total supply. Half of the coal supply is supposed to be anthracite. Some of the coal fields are located fairly near the coast, so that with the cheap labor available in China for mining it would be possible to ship the coal at a low price.

To sum up, while the exhaustion of our oil fields will deprive us of a native fuel, there is no cause for alarm. Domestic coal can be secured from Washington and from Alaska, where there is a supply sufficient to last us for hundreds of years. Besides this, our ports are open to the commerce of the world. The demand for coal will assist our trade by providing a return cargo for our ships, and the greater our export trade, the easier it will be to secure an adequate supply of coal.

THE RAILWAY FUEL PROBLEM OF THE PACIFIC COAST

BY J. C. MARTIN, JR.,[1] SAN FRANCISCO, CAL.

INASMUCH as fuel represents the second greatest item of the operating cost of a railroad, its importance cannot be underestimated. In order to have a clear understanding of the amount of steam fuel annually used by the Pacific Coast railroads, it is first necessary to know to a reasonable degree of certainty the quantity that must be provided and how its transportation can most expeditiously be arranged for to meet the demands of service.

In the states of Washington, Oregon, California, Nevada and Arizona there are now 4002 locomotives. Figuring that under normal operating conditions the modern locomotive consumes daily an average of 10 tons of coal, and that 90 per cent of the locomotives are used daily, in order not to underestimate the amount of fuel required, we find that the total fuel consumption per year is 13,146,570 tons. Considering the average B.t.u. content of the coal used as 12,500 per lb. and that 4 bbl. of fuel oil (42 gal. per bbl.) of 18,500 B.t.u. per lb. is equal to one ton of this coal, we have an equivalent of 52,586,280 bbl. of fuel oil required annually.

With this information in hand and considering that any hydroelectric development which would effect steam railroads by putting into use electrical units on certain divisions instead of steam-operated locomotive units would, in the development of our Pacific

[1] J. C. Martin & Co., Mem. Am.Soc.M.E.

Coast section during the next twenty years, call for further steam locomotives, to the extent that the total number of locomotive steam units will be substantially the same as today, it is then necessary to determine where the segregation of fuel oil and coal can best be made to serve the respective state mentioned from an economic point as well as a conservation of supply for the next twenty years.

Of first consequence is the matter of securing an adequate supply to meet the demands of service, for obviously without fuel operation ceases; and secondly, to lay down the most economical fuel to use in that particular state or territory in which the locomotives are operating, the kind of fuel used being governed very greatly by the transportation costs plus the fuel costs overlapping the equivalent B.t.u. value of the coal or fuel oil.

It is extremely difficult to assume what the future has in store in the way of railroad-locomotive fuel oil, as predictions in the past have been so materially upset through the development of new oil fields of consequence even in the past two years, which today have a direct bearing on the fuel-oil situation in California and the Pacific Coast, that the best we can say at this time is that, in view of reliable statistical information readily obtainable on the coal supply, there is sufficient fuel oil and coal directly within or immediately adjacent to the states of Washington, Oregon, California, Nevada and Arizona for the next twenty years, if properly segregated, conserved and restricted to the districts in which it should be economically used. This leaves fuel oil for railroad use entirely within the state of California, should the present processes now in the state of perfection, involving improved methods of cracking and refining, materially reduce the amount of fuel oil over that at present being produced to such an extent that no shipment out of California to other adjacent states could be made without detracting from California railroad requirements. It is quite true that it is within the possibility of cracking processes to materially increase the output of the lighter fractions in the crude so as to leave only a relatively small fraction of fuel oil, yet there is a question just how far practically this will go, as no means or system has yet been devised to properly handle in the locomotive firebox, for combustion purposes, or in fact the combustion chamber of any furnace, the so-called pitch or coke which is the final issue of the ultimate cracking process. This pitch has given considerable concern in firing owing to its adhesive nature.

Again, we find that the production of California crude oil has materially increased in 1921 over 1920, the total production in 1921 being 114,849,924 bbl. which exceeds the 1920 production by 9,128,738 bbl., and that the total crude oil stocks on December 31, 1921, were 35,021,912 bbl. as against 22,240,271 on December 31, 1920. The storage increase during the year being 12,781,641 bbl. and the daily gain 35,018 bbl.

At the present point it is illuminating to call attention to the report of the Fuel Committee of 1917, appointed by Governor Stephens to investigate the consumption of fuel oil. That part of the Committee's report and findings in reference to the consumption of fuel oil keeping pace with the production is herewith set out:

> The consumption in 1916 outran production an average of 1,100,000 barrels per month and 35,650 barrels per day.
>
> During the first five months of 1917, consumption outran production 5,415,000 barrels, being 1,083,000 barrels per month and 35,860 barrels per day.
>
> Consumers of California petroleum will shortly face a condition of decreasing production and increasing demand. This condition points inevitably to the necessity of developing other sources of fuel or power.

There is no question but what this committee used extreme care and handled the situation in a masterful manner at that time, but as previously stated, it will always be extremely difficult to determine, with any degree of certainty, just what the future sets forth in the way of fuel-oil supply and this is no better evidenced than by the Standard Oil Company's report of 1921, which shows that the production of crude is now 35,018 barrels per day ahead of the consumption, whereas in 1917, production of crude was 35,860 barrels below consumption.

At the outset the logical thing to do is to use the kind of fuel best and most economically obtainable in sufficient supply in that particular state of our Pacific slope where it is best found. As long as fuel oil is produced in California in sufficient quantity to ship to other adjacent states for railroad use, it is the ideal locomotive fuel for the railroads of such states to buy, provided suitable contracts to give them a reasonable assurance of at least three years' time can be entered into, and even on the basis that transportation costs on a relative B.t.u. basis of oil vs. coal show coal to be equal in price to fuel oil. This latter statement requires an explanation in that the modern fuel-oil-fired steam locomotive is conservatively 10 per cent more efficient than the same locomotive coal-fired either by hand or automatic stoker. The stoker as applied on the locomotive does not show the same degree of efficiency as compared to oil firing as does the automatic stoker applied to land-fired boiler furnaces shows to oil firing. It is the ability to maintain a practically constant boiler pressure in the modern oil-fired locomotive within 5 lb. of the pressure for which the pop valves are set that brings about this increased efficiency, whereas it is impossible to do so in meeting the maximum demands of service with the hand firing of coal or by stoker firing, which latter simply accomplishes what man cannot do physically, but without any greater efficiency in fuel saving.

Again, the ability to increase the steaming radius of the oil-burning locomotive over the coal-fired engine, whether hand- or stoker-fired, is greatly in favor of the use of oil, it being possible, for example, on the Southern Pacific System in California to operate an oil-burning locomotive a distance of 537 miles in passenger service from Sparks to Ogden without taking oil, this being over two passenger divisions, whereas it would not be possible through the use of coal with the accompanying necessity of cleaning fires to operate these engines coal-fired over more than one division.

From an operating point of view, this makes available power in oil-burning locomotives not possible to obtain in coal-fired engines, and it is a generally accepted fact in operating that for every ten oil-burning engines fitted there is the equivalent of one extra engine available for service over coal-fired engines.

From the foregoing it would therefore seem that, as far as it is within our knowledge to know at this time, we have ample fuel in the Pacific states to meet the present demands, if proper judgment and regard are used in their distribution, and probably so for a period of twenty years to come.

In conclusion, we can justly expect that in view of the great economy of fuel in locomotive fireboxes and its ability to increase the steaming radius of the locomotive, as it were, making available the maximum operatable locomotive power for the hauling of tonnage, that oil fuel will have precedence in railroad use over any other land-fired uses, should, for any reason, steps in the direction of conservation be required to be taken on account of declining production.

THE MARINE FUEL PROBLEM OF THE PACIFIC COAST

By D. DORWARD, JR.,[1] SAN FRANCISCO, CAL.

In THE operation of the American Merchant Marine there is no one problem more vitally important than the question of fuel, it being the dominant factor attending steamship operation and the largest single item of cost entering into the operating schedule of a vessel.

The greater part of the fleet of vessels now operating from Pacific Coast ports of the United States use oil as fuel, and with the exception of Australian and Japanese bunkering ports, coal supplies for replenishing bunkering stations are brought from very distant points of origin and therefore the cost of bunker coal at foreign stations, and even at Pacific Coast ports, is very high—so much so that even at the present prices ruling for fuel oil the oil-fired vessel is the most cheaply operated from a fuel standpoint.

Fuel oil as a source of power is today receiving the closest attention by maritime interests, for the world's merchant shipping is now rapidly being converted to fuel oil. The advantages derived from liquid fuel instead of coal are so important, particularly in facilitating bunkering and increasing the steaming radius and conservation of labor on shipboard, that it will undoubtedly tend to rapidly increase the use of oil as fuel, particularly in view of the highly competitive situation developing between the merchant marine of Great Britain and the United States.

[1] Consulting Engineer. Mem. Am.Soc.M.E.

Statistics show that at the beginning of 1920 the world's merchant shipping approximated 55,000,000 tons, of which tonnage approximately 9,000,000 tons was already on an oil-burning basis and of which proportion approximately 1,000,000 tons was fitted for Diesel-engine drive. This amount of shipping fully employed would occasion a demand for fuel oil annually of approximately 90,000,000 bbl. In 1918–1919, 12 per cent of the total world's tonnage was fitted to use oil, while in 1920 it had increased to 18 per cent.

The change from coal to oil has been occasioned by two conditions: The conversion of coal-burning vessels to an oil-burning basis and the construction of motor- or Diesel-engine-driven vessels. The adoption of the internal-combustion or Diesel type of propulsive equipment is just beginning to assume important proportions in the United States; but in Great Britain and on the continent of Europe this phase of the development has been and is making rapid strides.

The motor-equipped ship has unquestionably a strong advantage in point of economy over oil-fired steam-equipped vessels; but it is expected that the change from coal to oil as applying on the world's shipping will be greater through the intermediate stage of oil-fired steam vessels, which it is expected will create a requirement of at least 10,000,000 bbl. of fuel oil for each million tons of shipping using oil as fuel. Practically all of the vessels in operation by the United States Shipping Board and under private American ownership are substantially on an oil-burning basis, there being 49.4 per cent of these ships exclusively oil burners, 23.3 per cent coal burners, and 27.3 per cent convertible to burn either coal or oil.

In 1920 the fuel-oil requirements of the United States Shipping Board were in excess of 30,000,000 bbl., and while this demand was somewhat curtailed during the industrial depression of 1920–1921, it is expected, however, that the resumption of international trade will not only revive but intensify the fuel requirements of the merchant-marine fleet.

The navies of the world are largely on an oil-burning basis, for the advantages of oil over coal for naval operations are of the utmost importance and undeniably make for greater efficiency. While the naval demand for fuel oil is small in comparison with that required by the merchant marine shipping, there are, however, about five million barrels required annually for the American Navy.

It is now more than evident that oil for merchant-marine transportation has assumed a standing of the utmost importance and it has been conceded by well-known authorities that the strength of this demand is such that if necessary it can and will divert from industrial purposes the quantity required for shipping interests. At any rate, the significance of oil in maritime matters explains to a considerable extent the present world-wide interest that has been shown in oil. Particularly Great Britain has, by her policy in acquiring foreign reservations of petroleum, indicated beyond question the great advantage of fuel oil for naval operations and ocean transportation, and which factors have in addition been the source of much activity in the United States.

In the use of fuel oil on board vessels there are many economical features involved which would make the continuance of the use of oil as a fuel for maritime purposes of the greatest importance, and which are briefly summarized as follows:

- More economical operation
- Reduced crew
- Greater cargo capacity of the vessel on account of its ability to carry oil in compartments not otherwise available for cargo, such as double bottoms, peak tanks, etc.
- Ability of vessel's propulsive equipment to render more continuous service, steady steaming and uniform speed, thereby tending for more efficient operation
- Lessened wear and tear on vessel's equipment, machinery, boilers, and reduced cost of upkeep
- Less frequent painting
- Preserving effect of oil on vessel's double bottom, it being rarely necessary to undertake the most expensive item of renewing tank tops in oil-burning vessels.

On large passenger vessels fitted for oil fuel it has been noted that an enormous saving in operating costs has been effected on account of lessened wear and tear on such items as carpets, draperies and cabin equipment.

The great problem confronting steamship operators today is the question as to whether the world's supply of petroleum is sufficient to sustain automotive transportation on land, industrial power plants, lubrication requirements of industry, and whether the supply will support the great change in the conversion of ocean shipping to an oil-burning basis.

Were the 55,000,000 tons of world's ocean shipping converted to an oil-burning basis, it would require an annual consumption of over 500,000,000 bbl. of oil, which represents nearly the total quantity of petroleum produced in the world today. While this consumption could, of course, be somewhat reduced by a more universal adoption of Diesel engines, it would, nevertheless, be of huge proportions.

Utilization of oil by ocean shipping, however, is today governed largely by the matter of price; and upon the production of the world's most extensive deposits being exhausted it is possible that some reduction may be forced in the amount of fuel oil used for maritime purposes. This possibility seems to have been lost sight of under the present competitive conditions existing and on account of the great advantages offered by the use of fuel oil at the present price level. Regardless of the future of fuel oil, the fact remains that it is now definitely involved in competitive shipping efforts and its use is fully expected to grow for a considerable period at least.

Powdered coal is still in an experimental stage and it is questionable if its use on board vessels could be attended with any degree of success. It is expected, however, that the development of automatic stokers for use on shipboard will aid materially in the continued use of coal for marine purposes.

The consumers of petroleum oil are now facing a condition of decreasing production and increasing demand, which condition points inevitably to the necessity of developing other sources of fuel for power.

Hydroelectric plants can aid materially in the conservation of fuel oil in the power they produce, but industrial plants, railroads, and similar institutions will eventually have to find other sources of power than that developed by fuel oil, in order to supply the increasing demand for marine purposes, although of the substitute fuels coal will undoubtedly occupy the chief position.

Even at this stage it is significant that coal is now being brought from Australian ports in American vessels using oil as fuel; and large steamship companies having many vessels usually confine that portion of their fleet operating in Pacific Coast waters to those vessels fitted for oil burning.

Approximately 60 per cent of the crude oil produced in California is refined, at least in part, before being utilized. The increased demand for gasoline and lubricants and the rapid strides in refinery efficiency are resulting in the refining of a constantly increasing proportion of the oil with a resultant smaller quantity available for fuel purposes. Practically 50 per cent covers oil exports to the Orient from California ports, though these exports are confined mostly to fuel oil to Hawaii, Central America and South America, gasoline and distillate to Australia, and kerosene to the Far East.

The demand for refined oil products is rapidly increasing and will be accelerated by the potential oil shortage in other fields of the United States and by the necessity of using California oils to offset this shortage. To meet this increasing demand, California oil must be used more efficiently and sparingly.

California now produces between one-quarter and one-fifth of the world's supply of petroleum oils and one-third of the United States' supply. Statistics show that to January 1, 1921, the United States had produced 5.4 billion barrels; and subtracting this quantity from the original supply of 11.3 billion barrels as estimated by the U. S. Geological Survey in 1918, would leave as a working reserve only 5.9 billion barrels, with the annual requirements running over half a billion barrels.

Important strides have been made in refinery efficiency, also in number of refineries. The refining capacity of the entire country increased 18 per cent during 1919 and 23 per cent in 1920. This increase in refinery capacity together with greater efficiency will certainly have the effect of reducing the quantity of oil available for fuel.

It is a fact, however, that petroleum cannot be expected to radically displace coal in industry and transportation, since a crude

petroleum production of about three billion barrels per year would be necessary to drive coal from its present position.

For the future, fuel oil will represent a reducing percentage of the crude petroleum produced, for the more specialized uses, such as automotive power, lubricants and chemical by-products are coming into more importance and must be considered in preference to the demand for industrial fuel. However, fuel in liquid or gaseous forms is of such importance and has so many advantages in convenience and efficiency that it may reasonably be expected to continue to supplant solid fuels, which solid fuels must take second place as regards certain industrial uses and marine propulsion.

The output of crude petroleum in the United States is conceded to have virtually reached its maximum, and as the proved fields of Mexico are showing a rapid decline, a marked falling off in imports from that source may be expected.

Cheap supplies of petroleum will soon be a thing of the past; and the answer to the domestic petroleum problem does not lie in importations from foreign sources.

Efficiency in production and utilization and supplemental sources of supply at home must share with foreign supplies the responsibility of sustaining those activities exclusively dependent upon liquid fuel, and of which none are more important than the question of fuel for marine purposes.

CONSERVATION OF THE FUEL SUPPLIES OF THE PACIFIC COAST[1]

By F. H. Sibley,[2] Reno, Nevada

The three papers presented have raised so many interesting points for consideration that a discussion of them becomes a somewhat difficult matter of selection. Reviewing the papers, four points stand out prominently:

1 The paramount importance of an adequate supply of fuel of one sort or another (regardless of other sources of power) if industrial activity is to increase or even continue at its present rate.

2 To maintain this supply new sources will probably have to be developed in the not distant future.

3 Conservation of present available supplies must be looked after.

4 If restrictions on the use of fuel oil become necessary because of a diminishing supply, such restriction should not be placed on the use of oil for locomotive and marine service, because of its great convenience as well as efficiency for such service.

The first point mentioned, i.e., the importance of an adequate fuel supply, may well pass without further discussion.

As to the second point, namely, that of developing outside sources of fuel supply, it would be interesting to learn what forces are holding back development in Alaska; whether satisfactory trade relations, tariffs, etc., will be established between Canada and other countries so that fuel can be profitably imported to the Pacific Coast states; whether supplies from Columbia, S. A., said to be one of the greatest potential oil-producing countries in the world will be available in this group of states through the Panama Canal; whether the Philippine Islands, said to contain vast supplies of coal and oil that are only awaiting capital for their exploitation, will serve as a source of supply for the Pacific Coast states; and whether the peninsula of Southern California has ever been extensively explored for fuel deposits.

The third point, conservation, constitutes the great ready-to-hand problem of engineers not only here but in most other parts of the country. There are two main factors, it would appear, in the conservation of our fuel supplies:

(*a*) Prevention of waste and (*b*) increasing the efficiency of power equipment.

Fuel wastes again may be classified under two headings: namely, direct waste and indirect waste.

Few outside the engineering profession and by no means all engineers realize how enormous these wastes are. The Bureau of Mines is authority for the statement that 122,000,000 gal. of gasoline, representing a value of $26,000,000, are wasted annually by evaporation from storage and transportation. It has also been stated that $4,000,000 are lost by fire, due mainly to electrical discharges at storage tanks.

A recent news item stated that 5,000,000,000 cu. ft. of natural gas was wasted from four wells in Texas in a period of a few weeks. Another stated that a 100,000-bbl. well ran wild for twelve days in Mexico. Similar losses are recorded weekly from almost every production center.

These are direct and obvious losses and if we examine into the less obvious wastes of useless activity we find the situation no less disheartening. For example the Bureau of Mines, again informs us that the needless use of passenger cars consumes a million gallons of gasoline a day. Wastes from leaky carburetors, idling motors, etc., amount to half a million more.

When we turn to the question of fuel efficiency in power equipment we see that real progress has been made in the past twenty-five years in that such efficiencies have been nearly doubled, but there is still room for improvement when we consider that of the total production of fuel for power purposes only a pitiful ten or fifteen per cent is transformed into effective work.

Estimates of time that fuel supplies will last are based, rightly enough, on the assumption that losses will continue to increase with consumption or at least will continue at somewhere near the present rate. But will they? And if not, how are we going to prevent it?

The following suggestions are most of them old. Some of them may be visionary. But the visionary things of today often become the realities of tomorrow. At any rate a discussion of them may be worth while, even if they should lead only indirectly to better conditions.

1 Getting a larger proportion of oil from the sand. Lewis of the Bureau of Mines estimates that an average of only 20 per cent of the total petroleum in the ground is recovered by present methods. In Louisiana and presumably in California also are crudes of such low gravity that they can not be removed by pumps at all. Driving off this oil by air or water has not, in the main, been very successful. What about the suggestion to mine the oil sand? The problem apparently presents no difficulties not met with in other forms of mines, and if these sands contain from 50 to 80 per cent of the original oil, mining them would seem to be a better proposition commercially than distilling oil shales.

2 Making greater use of slow sailing ships to transport cargoes not subject to deterioration.

3 Development of artificial fuels, mixtures of alcohol and benzol being an example.

4 More efficient prime movers. The advantages of the Diesel motor for marine service have been pointed out in Mr. Dorward's paper. Compounding it may give even better results. Should it be applied to railway locomotives as well?

5 The substitution of large central stations for small individual plants should, and doubtless will, go forward. The gain from this change is larger even than most people suppose. Small plants where the overall efficiency is probably not more than two or three per cent are still all too common.

6 More scientific study of storage and other field conditions both in coal- and oil-producing districts should be made. Problems like proper painting and roofing of oil tanks to prevent evaporation losses and fire losses due to electrical discharges need more systematic study.

7 Finally as to indirect wastes due to careless or useless activities. Here is where our economic education comes in. Will people in time become wise enough to realize the wickedness of using a 60-hp. automobile for pleasure purposes when 25-hp. might do as well? Will those who have no special business abroad learn to amuse themselves at home? Shall we ever learn to stop taxing ourselves for hauling thousands of tons of worthless literature and other junk in the mails?

While this is taking rather high ground, these are some of the things we must learn if we are to keep up the present rate of industrial progress and provide for all *worth-while* activities, without exhausting our supplies of fuel before we have learned perhaps better and cleaner methods of producing power.

[1] Introduction to the discussion of the preceding papers by Messrs. Delany, Dorward and Martin.

[2] Dean of the College of Engineering, University of Nevada. Mem. Am. Soc.M.E.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AIR MACHINERY

Efficiency of Single-Blow Pneumatic Hammers

Single-Blow Pneumatic Forging Hammers, W. H. Snow. The author starts with a general discussion of factors affecting the efficiency of self-contained pneumatic hammers and gives diagrams to explain the relation between the movements of the pump and hammer pistons.

The single-blow hammer described in the present article is based on the idea that with the valve designed so that more use can be made of the pump as a compressor and air can be led into the hammer cylinder, above as well as below the piston, there exist the elements of a control of the up-and-down movements analogous to that obtaining in the ordinary double-acting steam or air hammer.

The simplest design of such a valve is shown in Fig. 1. If the valve be moved from the hold-up to the hold-down position a single blow will be struck. Air compressed under the pump piston passes through the one-way valve B into the belt D, and by a passage not shown to the top of the hammer cylinder. The air below the hammer piston is exhausted through passages C in the tube and openings C' in the valve. This arrangement, however, is not as efficient as it might be. The blows will not be very powerful as compared with the pump pressure, and furthermore they can be produced only comparatively slowly.

Because of this another design shown in the original article has been worked out. In this both ends of the cylinder are brought into use and the pump works as a double-acting compressor.

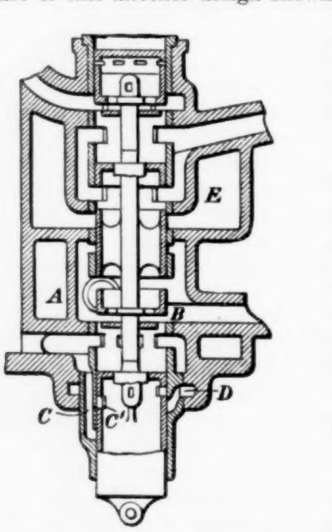

Fig. 1 Operating Valve of Single-Blow Pneumatic Forging Hammer

The governing is effected by a special rapid-acting unloading valve, which opens a by-pass F when the maximum pressure is reached. Finally, storage of the compressed air is arranged for in a reservoir formed in the cylinder-casting (which can, if necessary, be connected to an outside receiver to increase the storage).

The single-blow, hand-controlled, independent action in this case, where heavy blows can be struck at about one-third the rate of the automatic blow, becomes a real improvement, particularly in the larger sizes of hammers, enabling the miscellaneous processes of flattening, straightening, edging, setting, cutting off, stamping, etc., to be carried out with precision, speed, and safety. The order of events in the operation of the hammer, beginning with the valve lever in the raised position, is: (1) hold up; (2) hand blow (and hold down); (3) not working (hammer at rest, pump by-passed); (4) light automatic blows; (5) heavy automatic blows.

The heaviest blow than can be struck depends on the size of the reservoir, the pump displacement during the short time the hammer is falling being too small to affect the pressure. With a small reservoir the expansion will be considerable and the mean pressure and force of blow will diminish. The efficiency improves with increased expansion, but on the other hand the charging up of the reservoir ready for a second blow proceeds from a low pressure, and the work the pump can do in a given time is less than with a larger reservoir and smaller range of pressure. The best results are obtained with the latter, enabling the pump and motor to work up to their maximum capacity; but if the reservoir is too large, the time taken to charge up after a period of automatic working, during which the reservoir pressure may have run down, may be inconveniently long. Fig. 2 shows the results obtained with different reservoir capacities, ab and ab_1 being reservoirs of volumes 1 and 2, respectively, while cd is the hammer-piston displacement. The efficiency for ab (ignoring compressor and clearance losses) $= \frac{acdg}{acd_1g}$ and for $ab_1 = \frac{acdh}{aceh}$. Suppose $cd = ab$ and pressure = 30 lb. per sq. in. (gage). Then efficiency (1) = 90 per cent and (2) = 78 per cent. The work obtained is given by the numerator. The work done in recharging is $aec - c_2cc_1$ and $afc - c_3ec$, respectively. The ratio of work obtained in the two cases is 1:1.30, and of work done, 1:1.50. More work to the extent of 50 per cent can be done in the air with the larger reservoir.

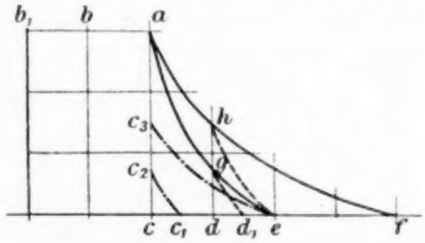

Fig. 2 Diagram Showing Hammer Results Obtained with Different Reservoir Capacities

The work obtained is 30 per cent greater, the efficiency being less.

While some hammers constructed on these lines have given satisfactory results over a considerable period, there are certain objections to the design, such as the extra first cost. Also, a single mishap, such as the failure of a valve or spring, may lead to unsatisfactory performance of the hammer through possibility of wrong assembling, and this latter might easily take place where the control valve and other parts are assembled by men accustomed to deal only with the ordinary plain equipment of a forge. An analysis of conditions therefore leads the author to take a rather gloomy view of the possibilities of single-blow pneumatic forging hammers. (*Engineering*, vol. 114, no. 2952, July 28, 1922, pp. 98 to 109, illustrated, *d*)

ENGINEERING MATERIALS (See also Machine Tools, Testing and Measurements, and Welding)

Lecfurite—High-Resistance Alloy. Brief and incomplete data on a alloy developed by an English company for use in place of such materials as nichrome.

The melting point of the material is said to be approximately 1550 deg. cent. (2822 deg. fahr.), tensile strength, 42.26 tons; elongation, 27.5 per cent; reduction of area, 68 per cent; and Brinell hardness, 187. The material can be welded, rolled, drawn, or stamped, and resists the action of most acids and alkalies. No data as to its composition are given. (*Machinery* (London), vol. 20, no. 511, July 13, 1922, p. 552, *d*)

FOUNDRY

Making High-Grade Castings Direct from the Ore, F. H. Bell. Description of a process experimentally used at the Ford Motor Works. The process has not yet been carried out to the stage where it can be called successful, but it is said that it is by no means a failure.

In this process (used at the River Rouge branch) the metal is obtained direct from a blast furnace of a construction somewhat different from that of the usual type. Different grades of ore are mixed with the view to getting the required chemical content. As ore is never uniform, every batch has to be analyzed to make sure

that it is right. The least error in charging a furnace may make a big difference in the resultant metal.

From the furnace the iron is poured into a big container, in which the metal is held while the chemist is making his calculations. This container is built on the principle of a thermos bottle, Fig. 3. It consists of one shell within another with an airtight space between, the inner one being lined with firebrick. At one end is a tap hole near the bottom, while at the other end and on the top is an opening into which the metal is poured from a 75-ton ladle.

A certain number of cupolas are always in operation melting scrap from former heats, pig iron and such special metal including steel scrap as it may be desired to mix with the furnace iron to bring it to proper analysis. The analysis of this cupola metal is fairly well known in advance and the additions are determined on the basis of the analysis in the thermos-bottle container.

The metal which is very hot when put in the container will remain hot for as long as five hours. Casting direct from the ore, therefore, does not differ essentially from the ordinary processes, except that it represents a very large outlay of money and could not be applied to a foundry of ordinary size. (*Canadian Foundryman and Metal Industry News*, vol. 13, no. 7, July, 1922, pp. 17–18, 2 figs., *d*)

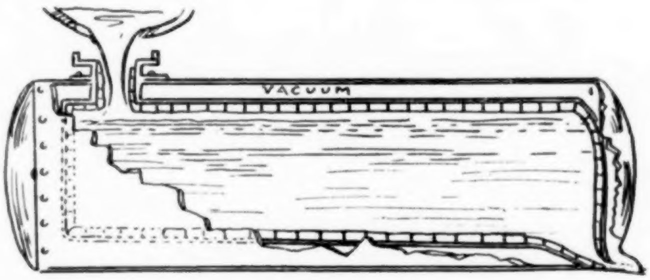

Fig. 3 Sectional View of Mixer Used by the Ford Motor Co. in Making Castings Direct from the Ore

FORGING (See Air Machinery)

FOUNDRY

Gearing and Ladle Operation. Analysis of the performance of various types of gearing as affecting ease in handling and safety of ladle operation.

The conditions of operation of gearing on ladles are rather strenuous. With most styles of geared ladles the expansion and contraction affect the alignment of the gearing. In many foundries the lubrication of ladle, gears, and trunnions receives little attention and this results in excessive wear and trouble. Unless gears, cups, and oil holes are located so that the lubricant gets to the bearings and gears in sufficient quantity, the ladle gearing will suffer, no matter how much care is exercised.

When lost motion is present in the gearing, a dangerous drop of the ladle occurs during pouring, caused by the flow of the metal. This usually results in a splash of molten metal, which may cause serious injury to the men around.

On the other hand, if the gears are too tight and bind, pouring becomes difficult and may lead to cold shuts and misrun castings.

The oldest type of gearing applied to a ladle was the worm, and it is still quite extensively used. Spur-geared ladles appeared in this country about 30 years ago in pipe foundries where a ladle operating faster than worm gearing permitted was desired. The most recent type is the helical form, which is said to be more efficient than either of the two older types. In this the housing is mounted on the trunnion and has no attachment to the bail except through a sliding support. This makes the tilting mechanism an independent unit, with the result that the alignment of the gears is not affected by the distortion of bail or bowl or by wear on the trunnion journals. In addition to this the gear is self-locking, requires little power to operate, and permits a wide range of tipping speeds.

The location of the trunnion is important, as shown by deductions from curves in the original article giving the turning moments of a 10-ton ladle at various angles. From these it appears that moving the trunnion 1 in. upward or downward changes very materially the moment required to tip or right the ladle.

The original article shows also how to calculate the force required on the handwheel for operating a given ladle. (Paper presented at the Rochester meeting (June 5–9, 1922) of the American Foundrymen's Association, abstracted through *The Foundry*, vol. 50, no. 16, Aug. 15, 1922, pp. 682–684, *p*)

FUELS AND FIRING

Colloidal Fuel, Lindon W. Bates. A description of the manufacture and some of the uses of colloidal fuel.

Colloidal fuel is a mixture containing pulverized coal or coke stably suspended in mineral oil or a blend of oil and liquid derivatives of coal.

To prevent settling out of the coal a stabilizing treatment is given. For this the following may be used singly or in combination. In the first place, the solid fuel may be ground to a fine state of subdivision, which is, however, a somewhat costly method. Next comes saponification, which may be accomplished by adding to the oil a soap such as a lime-rosin soap, thereby "fixating" it. About one per cent of rosin and one-half per cent of lime will serve.

Resinate of calcium gives the most persistent stability. Peptization may also be used. This is obtained by digesting bituminous coal with a moderate percentage of creosote or other coal distillate under a heat treatment of 180 deg. fahr. for over an hour.

The plant necessary for the production of colloidal fuel is described in general terms in the original article and is said to be comparatively simple. The original article presents a general discussion of the prospective field for colloidal fuel and data of some of the tests, from which it would appear that colloidal fuel is suitable for marine use under practically the same conditions and with as good results as Navy oil. Certain grades of colloidal fuel were submitted for a rating to the U. S. Fire Underwriters' laboratories and have been in general approved by them, as it was found that they present no objectionable characteristics for use as a fuel for ordinary burning purposes as compared with ordinary fuel oil.

The flash point was found to be very much higher than usual for fuel oils. The apparent ignition temperature is likewise relatively high and the material shows no tendency toward spontaneous ignition.

The application of colloidal fuel to railroad purposes is discussed in some detail. (*Steam*, vol. 30, no. 2, August, 1922, pp. 41 to 44, *dg*)

Airspray for Boiler Furnaces

Air Spraying the Fuel. Description of an appliance for supplying air to the fuel bed in a manner believed to insure complete combustion.

The Airspray, as the device is called, comprises an air-inlet pipe fitted with a special silencing device. This pipe is carried from above the boiler to the top of the furnace front and here joins a specially constructed air-heating pipe made to stand high temperatures. This air-heating pipe is passed through the furnace front and is carried almost in contact with the furnace crown to a high-temperature air chamber built of firebrick within the combustion chamber.

The bottom of this chamber, Fig. 4, is formed by a special spraying plate. An air-balancing forked sprayer is fitted to the furnace-front end of the high-temperature air pipe and is controlled by a small valve.

The amount of air entering the air-inlet pipe is regulated by the steam coming from the air-balancing forked sprayer. The air is raised to a very high degree of temperature as it passes over the furnace through the heating pipe, when it is discharged through the open shaft into the hot-air chamber, and thence through the perforated plate in a fine spray, combining with the unburned gases generated in the furnace. It is claimed that by this method the unburned gases are consumed immediately after they have passed over the furnace bridge and before they have passed through the combustion chamber.

It is of course possible to overdilute the gases. This is said to be taken care of by the air-balancing device. It is also claimed that

the device makes combustion smokeless. Of course, if carbon particles contained in the otherwise unburned gases are consumed within the combustion chamber instead of passing through the flues into the atmosphere, smokeless combustion must result. (*Practical Engineer*, vol. 66, no. 1848, July 27, 1922, pp. 52 and 53, 2 figs., *d*)

GLASS MANUFACTURE

Balanced-Toggle Mechanism for Pressing Glassware

Balanced-Toggle Mechanism for Pressing Glassware. In the manufacture of pressed glassware with automatic machinery a good deal of trouble has been experienced due to the inability of the ordinary automatic press to distinguish between an over- and an under-weight charge of glass in the mold, and to apply automatically pressure of the proper degree. To meet this condition the compound balanced-toggle principle has been employed in automatic glass presses by William J. Miller, and it is said that the balanced toggle is capable of applying the correct degree of pressure to the glass, be it cut under or over weight.

As the same principle may be applicable in other lines of manufacture, some data are reproduced here.

Fig. 5 illustrates at a glance the principle of the toggle. The curved line shows how the pressure mounts and the speed decreases as the plunger advances on its working stroke, and vice versa on its idle stroke. The piston area being 78.54 sq. in. and the effective air pressure 39.5 lb., by neglecting friction the piston delivers to the toggle 3000 in-lb. for the first inch period of piston travel, and as the plunger is caused to travel 2.3 in. per inch of piston travel, it is evident that the pressure applied to the plunger is 3000 divided by 2.3, or 1315 lb. The last inch of piston travel results in only 0.03 in. travel of the plunger, therefore 3000 divided by 0.03 equals 100,000 lb. average pressure on plunger during the last inch of piston travel. This is the maximum pressure. If more glass be deposited in the mold, so the plunger can penetrate only to within 0.04 of its maximum, the total plunger pressure will be reduced $66^2/_3$ per cent or to 33,333 lb. Add enough glass so the plunger penetrates only to within 0.13 of its maximum, then the total plunger pressure will be still further reduced to 13,636 lb. Therefore as more glass is deposited in the mold, the plunger cannot penetrate so deep and consequently less pressure is applied.

By following the curve on the diagram it will be observed that, as the plunger advances into the mold, its speed of travel decreases and its power increases. Experience tells one that as the plunger advances into the glass, to propel it, due to the decreased fluidity of the glass and to the gradually decreasing space between plunger and mold wall through which the glass must be forced, an enormous pressure is required.

This peculiarity is also taken advantage of to provide a quick, reliable and simple adjustment of maximum pressure applied to the plunger. The toggle mechanism and press cylinder are suspended from the top girder of the machine by a screw secured to the top cylinder head, and this screw is provided with adjustment nuts above and below the top girder, thereby adjustably securing and locking the entire pressing mechanism at any desired height.

To reduce the pressure from its maximum of 100,000 lb. as shown in Fig. 5*e* to 33,333 lb., the operator simply lowers the pressing mechanism approximately 0.04 in. If only 7500 lb. pressure is required, the pressing mechanism is lowered so the toggles assume the position shown in Fig. 5*d*. If adjusted as in Fig. 5*c*, but 2803 lb. are applied to the plunger, and at the beginning of its stroke, Fig. 5*b*, but 1315 lb. are applied to the plunger.

It would require a monstrous cylinder with a $56^1/_2$-in. bore, supplied with an enormous amount of compressed air at 40 lb. per sq. in. pressure, to deliver the same degree of power to the plunger that is obtained with a 10-in. cylinder transmitting its power through this toggle at its maximum.

The area of a 10-in.-bore cylinder is 78 sq. in. and the area of a $56^1/_2$-in. cylinder is 2500 sq. in. Therefore, the direct-acting press will require (2500 ÷ 78 =) 32 times as much air as the toggle press at its maximum.

At the other extreme of the toggle which is at the beginning of the plunger's descent, the power applied to the plunger is over (1315 lb. ÷ 40 =) 33 sq. in. in area, which is the area of a $6^1/_2$-in.-bore cylinder. In other words, the plunger starts down with a power equal to that of a $6^1/_2$-in.-bore direct-acting cylinder and terminates with a power equal to that of a $56^1/_2$-in.-bore direct-acting cylinder. Between these two extremes the increase of power is gradual.

No system of springs, cushions, air-control valves, etc., however ingenious and complicated, can perform the functions possessed by this correctly designed and simple compound balanced-toggle pressing mechanism. The simplicity, convenience, and freedom from breakdowns appeal to the practical glass man.

For making of high-grade pressed ware requiring a great amount of pressure correctly applied, the toggle is practically indispensable. It required years to develop this toggle to its present degree of perfection according to the statement and data presented in the original article. (*The Glass Worker*, vol. 41, no. 43, July 22, 1922, pp. 11, 29 and 30, *d*)

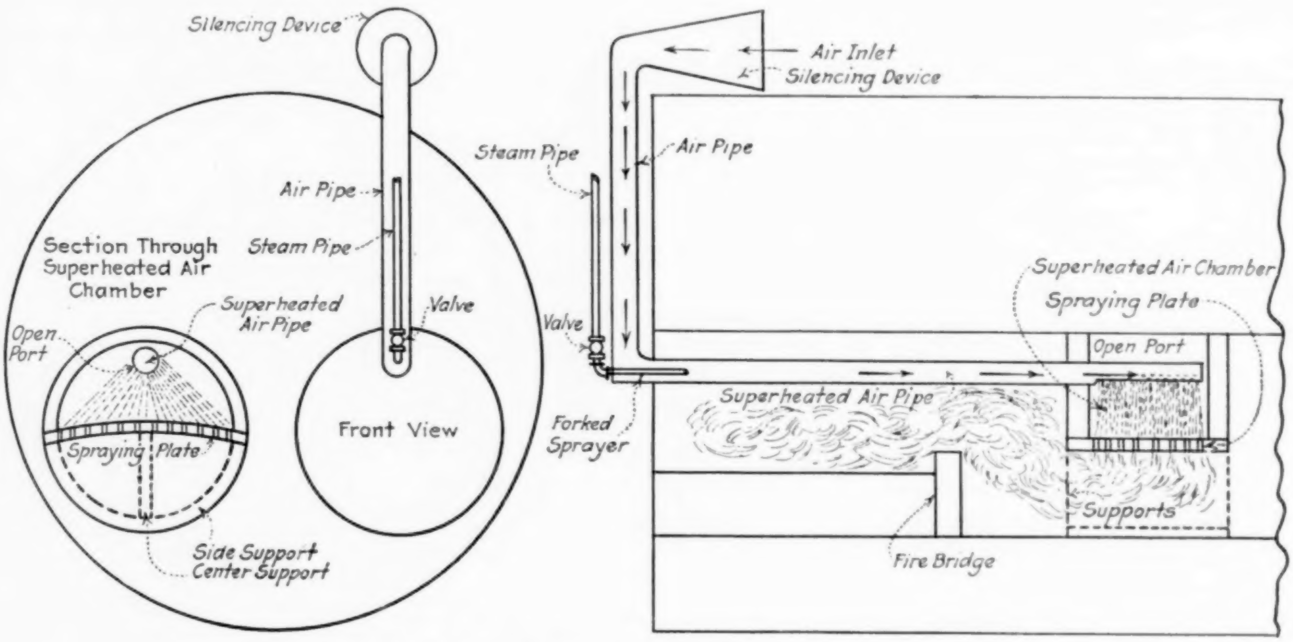

Fig. 4 Airspray Fitted to a Lancashire Boiler

HYDRAULIC ENGINEERING

THE CALIFORNIA PIPE METHOD OF WATER MEASUREMENT, Blake R. VanLeer. The method described is intended for use by the man on the job who has only ordinary tools at his disposal, such as the irrigation farmer or the man operating trench pumps. It is applicable only where the discharge of the water is not submerged or under pressure.

The necessary apparatus is very simple and consists only of a tee (same size as the discharge pipe), nipples, a spirit level, and a 2-ft. carpenter's rule.

The California pipe method of water measurement is based upon the principle that if water is delivered to a short pipe nipple with a zero or at least a very small velocity head, then for the same size of pipe and the same quantity the depth of water in the pipe will always be the same.

In the Hydraulic Laboratory of the University of California the following general formula was derived:

$$Q = K\,(D - a)^{1.88}$$

(See Report on the Measurement of Water Discharged from a Short Horizontal Pipe, a thesis by Ejnar Smith and Clarence A. Pollard, submitted in partial satisfaction of the requirements for the degree of B.S. in Mechanical Engineering at the University of California, May, 1921.) In this formula—

Q = quantity in second-feet
K = a constant depending upon the diameter of the pipe
= $0.0116 + 0.00787\,D$ in this general case
D = diameter of the pipe in inches
a = distance in inches from the upper inside surface of the pipe to the surface of the flowing water, measured in the plane of the discharge end of the pipe.

The formula has been checked by experimentation with pipe up to 6 in. in diameter and has been found to be quite accurate. The error was at all times less than 5 per cent.

The original article describes the apparatus and gives two sets of curves from which Q may be obtained directly from experimental data without the use of logarithms or a slide rule. One set of the curves gives $(D - a)$ plotted as abscissas on logarithmic paper against Q (quantity in second-feet) as ordinates. The other set of curves gives the relation betwen the distance a and the quantity Q in second-feet, thus avoiding the use of logarithmic paper. Finally, the original article gives tables that make the use of charts unnecessary. The original article also describes in detail the method of setting up the measuring apparatus, which is quite simple, however. (*Engineering News-Record*, vol. 89, no. 5, August 3, 1922, pp. 190–192, 3 figs., *p*)

HYDRAULIC MACHINERY (See Shipbuilding)

INTERNAL-COMBUSTION ENGINEERING

DESCRIPTION OF DIESEL-TYPE ENGINE OF UNCONVENTIONAL DESIGN. The engine consists of an open-ended cylinder, or rather two cylinders bolted together in the middle. Though operating together, these two cylinders are to a certain extent independent in action. Moreover, the cylinder, together with its water jacket and scavenging and exhaust branches, is free to reciprocate relatively to the two cylinder covers provided at its top and bottom. The covers themselves are made in the form of stationary pistons with gastight rings, and each cylinder cover contains a fuel valve and starting air valves.

There are certain obvious theoretical advantages in this design. The scavenging system is exceptionally good, since a thorough scavenge is obtained both top and bottom, owing to the scavenge and exhaust ports being at the opposite end of the cylinders, this, in addition, eliminating certain awkward heat stresses. The engine is well suited to accommodate expansion due to heat, which is one of the biggest problems, especially in connection with the design of high-powered engines. The cylinder is entirely free to expand both axially and radially. The combustion space takes the form of a plain cylindrical tube, entirely surrounded by cooling water and free from any valve holes. The rubbing speed of the piston is about 70 per cent of the normal, owing to the cylinder having a motion nearly synchronizing with that of the piston.

The engine upon which tests were run and which is the first of its type yet built, has two working cylinders of $11^1/_2$ in. bore and $14^1/_2$ in. stroke, and develops 240 b.hp. at 250 r.p.m. It was found to have a mechanical efficiency of 65 per cent, which is considered to be very satisfactory, since the scavenge pumps and air compressor are both overdesigned. This motor will be installed as an electric generating engine in one of the large Diesel-engined ships now being equipped by the North British Diesel Engine Works with their four-cycle Diesel motors. It is stated that the builders are considering the construction of a three-cylinder set to develop 2250 i.hp. or about 2000 shaft hp. It will have cylinders $24^1/_2$ in. bore with a piston stroke of 44 in. and will run at 100 r.p.m. (*Practical Engineer*, vol. 66, no. 1846, July 13, 1922, p. 26, *d*)

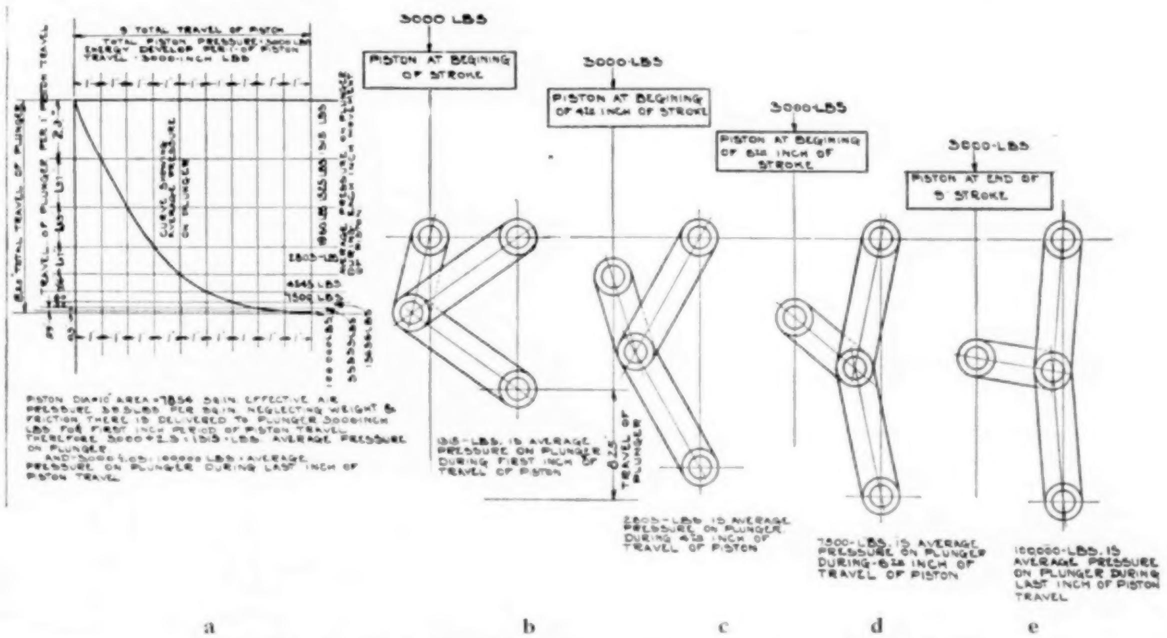

FIG. 5 MILLER COMPOUND BALANCED TOGGLE AS APPLIED TO PRESSING GLASSWARE

CARBURETOR ADJUSTMENT BY GAS ANALYSIS, A. C. Fieldner and G. W. Jones. Data of experimental work in the determination of carbon dioxide in exhaust gas from motor-vehicle engines, thus having a direct bearing upon carburetor adjustment.

The percentage of carbon dioxide in the exhaust gas bears a direct

relation to the completeness of combustion and to the air-fuel ratio.

Curves are given showing the carbon dioxide percentage relation to the air-fuel ratio and also to completeness of combustion, both by laboratory and road tests.

Characteristic curves are given of two types of carburetors, the results of which were plotted from road tests, showing how the air-fuel ratio changes with change of mixture rate through the carburetor.

Methods of procedure for sampling exhaust gases while adjusting carburetors, on the road are given, and a portable carbon dioxide indicator is described. Examples of carburetor adjustment by gas analysis are also given. (*Journal of Industrial and Engineering Chemistry*, vol. 14, no. 7, July, 1922, pp. 594–600, 10 figs., *eA*)

MACHINE DESIGN (See Foundry)

MACHINE PARTS (See Railroad Engineering)

MACHINE TOOLS

Diamond Alloy—A New Cutting Metal. Data on a non-ferrous alloy composed mainly of chromium, molybdenum, and tungsten. It is said that tools made of this alloy may be used under conditions of feed and speed that raise the temperature of the tool to the fusion point without producing softening of the cutting edge. The metal is non-magnetic.

The alloy cannot be forged and tools made from it are cast in permanent molds. Some tools are cast on a steel core or center while others are made entirely from the alloy. Diamond alloy can be welded to steel as for making laminated tool bits, which consist of a strip of the alloy welded to a strip of chrome-vanadium steel.

The following is quoted as results obtained with tools made with this alloy:

"In milling cast iron the cutter was run at a speed of 370 ft. per min. with a feed of 15 in. per min. and a 1/8-in. depth of cut. In turning machine steel having a carbon content of from 0.35 to 0.40 per cent, the tool was operated at a cutting speed of 125 ft. per min. with a feed of 5/16 in. per revolution of the work and a 1/8-in. depth of cut. In turning a chrome-nickel steel shaft, the cutting speed was 125 ft. per min. with a feed of 1/32 in. per revolution of the work and a 7/32-in. depth of cut. (*Machinery*, vol. 28, no. 12, August, 1922, pp. 958–9, 2 figs., *d*)

MECHANICS

Contribution to the Problem of Stability of Rotating Shafts, Dr. Theodor Poeschl. Mathematical discussion of the problem. The author endeavors to establish the existence of a critical range of the second order differing from the critical velocity proper, this range denoting a periodical variation of motion appearing for certain angular velocities, and which, should it prove to be unstable—a fact which has by no means been fully established—would make itself noticeable during the passage of the shaft through the range in the course of speeding up to operating velocity.

The analysis given in the article does not solve the problems arising during the process of getting the shaft up to speed, but expresses them in the form of an equation of which the method of solution is not given. (*Schweizerische Bauzeitung*, vol. 80, no. 3, July 15, 1922, pp. 23–25, 1 fig., *m*)

METALLURGY (See Machine Tools)

POWER-PLANT ENGINEERING

Steam-Pipe Coverings at High Temperatures. Data of tests at the National Physical Laboratory and of apparatus designed by C. Jakeman. The covering under test was put on mild-steel pipes of 4 in. inside diameter with the pipe ends closed by blind plate flanges, radiation from these blank ends being taken care of by a proper correction.

The two pipes under test were respectively 13 3/4 ft. and 2 ft. in length. When the heats lost by the two pipes at any particular temperature are determined, the difference between the two heat values represents the loss of heat in a pipe of the differential length, namely, 11 3/4 ft. The pipes were heated electrically. The original article describes in detail the installation and methods of calibration.

The following data were obtained in testing an asbestos covering of very good quality:

Mean temperature of pipe	804 deg. fahr.
Mean temperature of air	68 deg. fahr.
Mean difference of temperature	736 deg. fahr.
Energy supplied to long pipe	1,216 watts
Energy supplied to short pipe	222 watts
Net energy required by the test length of pipe	994 watts

The net energy required for the bare pipe having been found in previous tests to be 13,240 watts, the efficiency of the cover is—

$$\frac{13{,}240-994}{13{,}240} = 92.5 \text{ per cent}$$

(*Engineering*, vol. 114, no. 2953, August 4, 1922, p. 155, 2 figs., *e*)

Ljungstrom Air Preheater for Boiler Furnaces

Ljungstrom Air Preheaters for Boiler Furnaces. Description of a novel type of air preheater designed by the originator of the Ljungström steam turbine and turbo-locomotive, the peculiar feature of this preheater being that it carries heat continuously in a mechanical way from the flue gases to the incoming air.

Fig. 6 shows diagrammatically the internal arrangements. Fresh air is drawn by a fan into the upper portion of the casing, which is divided into two parts by a vertical partition. The air is confined to one side of the partition, and passes downward to a similar semicircular chamber through the body of a porous cylindrical drum. The flue gases from the boiler traverse the apparatus in the reverse way, entering a lower semicircular chamber and passing upward through the drum to the upper chamber, whence they are exhausted and impelled to the stack by another fan. The porous drum is kept in a state of continual slow rotation, so that the part heated by the flue gases is constantly passing to the other side of the apparatus and giving up its heat to the cold air sweeping through it. Similarly, of course, the cooled part of the drum is continually returning to be reheated by the flue gases. It will be observed that there is no transference of heat through metal in the process. A deposit of soot or tarry matter, therefore, does not have any very serious effect upon the action of the apparatus, which, moreover, may be cleaned in a few moments by means of a steam jet. The latter blows the soot along with the air going to the furnace, so that what heat value it has is returned to the fire.

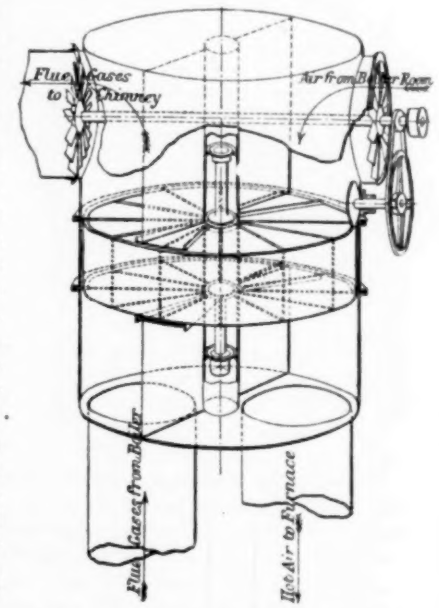

Fig. 6 Ljungström Air Preheater for Boiler Furnaces

The porous drum is built of thin sheet steel and divided into sectors by radial plates which serve as stiffening spokes. Each sector is packed with a number of thin sheet-steel plates, which are kept apart by a large number of small channel-shaped strips spot-welded to their sides.

One of the first Ljungström air preheaters was installed in conjunction with a pair of small hand-fired boilers already in service. The preheater was mounted over the flue at the rear end of the boilers and the flue gases returned to the flue outside the wall.

The hot air was led along the top of the boilers to the ashpits. A small motor of about one-half horsepower carried on a bracket from the boiler-house wall drove the fans and the rotors of the preheater.

Tests on a boiler were carried out with and without the preheater in operation. The boiler was of the return tubular type, with a heating surface of 66.3 sq. m., and fitted with an ordinary grate of 0.6 sq. m. area for hand firing. The conditions of the test were somewhat unfavorable to the preheater, as the grate area of the boiler was so small in relation to the heating surface that the waste gases normally left the boiler at an unusually low temperature. Moreover, the upper part of the boiler and the steam dome were unlagged, so that the whole efficiency was lowered by excessive radiation losses. All measurements were made in a careful and scientific manner, and the coal and the waste gases were analyzed. The results published in the official report of the Steam Boiler Association are given in Table 1.

TABLE 1 TESTS OF LJUNGSTRÖM AIR PREHEATERS

	Test 1, without Preheater		Test 2, with Preheater	
	Heat units per kg. coal	Per cent	Heat units per kg. coal	Per cent
Heat transferred to steam.......	4509	66.9	5370	77.6
Heat lost in waste gases........	1031	15.3	401	5.8
Heat lost by unburnt gases......	243	3.6	125	1.8
Heat lost by radiation, ash, etc...	957	14.2	1024	14.8
Net calorific value of coal....	6740	100.0	6920	100.0

It will be noted from the first line of Table 1 that the efficiency of the boiler was raised from 66.9 per cent to 77.6 per cent by the use of the air preheater, the saving of fuel being thus about 16 per cent. No sign of overheating of the grates was observed. The rate of combustion was about normal for such grates, being 113.2 kg. of coal per square meter per hour. The air for combustion was raised from 29 deg. cent. to 135 deg. cent. by the preheater, and the flue gases were at the same time cooled from 222 deg. to 123 deg. cent.

The original article gives data of another test on a water-tube boiler.

It is claimed that the Ljungström air preheater as an alternative to an economizer is not only more efficient but is smaller, lighter, and cheaper both in first cost and maintenance, which the article attempts to prove by showing, side by side, an air preheater and an economizer drawn to the same scale and expected to achieve the same results. (*Engineering*, vol. 114, no. 2949, July 7, 1922, pp. 24 to 27, 12 figs., *dA*)

PRESSES (See Glass Manufacture)

PUMPS

Combined Centrifugal and Rotary Pump

Combined Centrifugal and Rotary Pump. Description of a pump known as the "Drum," which combines centrifugal action with that of a direct-acting piston pump.

The pump (Fig. 7) consists of a revolving piston sweeping out the cylinder at every revolution. The revolving piston dips into a revolving valve of cylindrical drum, the openings of which are so arranged that the piston passes through without slip, back pressure, or undue friction. When the revolving piston moves around from the revolving valve, a vacuum is formed into which the water flows and is forced around in the front face of the piston.

Contrary to what happens in case of the ordinary rotary pump, the present type passes the water through in one continuous flow without interruption and utilizes the power in the momentum of the moving column. As there is only one rotary working piston, the friction and strain on the gear wheels and bearings of driving a second revolving piston (as in the ordinary rotary) is avoided.

No air vessels are required and the pump works equally well in either direction and at slow speed. The quantity of water delivered is varied by changing the speed, in addition to which a by-pass fitted with a regulating valve may be used to take care of excess water delivered by the pump; throttling of suction or delivery pipes cannot be used, however. (*Practical Engineer*, vol. 66, no. 1849, August 3, 1922, p. 74, 2 figs., *d*)

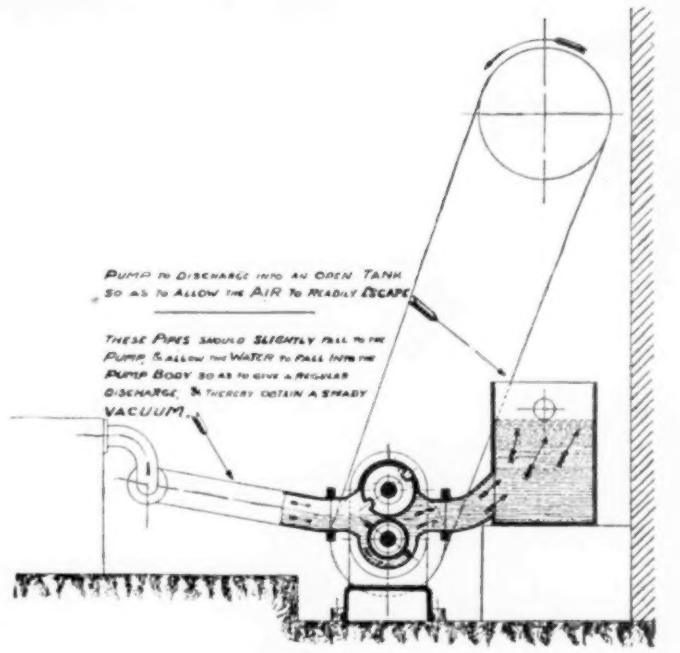

Fig. 7 Drum Pump Applied to Suction Boxes of Paper-Making Machines

RAILROAD ENGINEERING (See also Testing and Measurements)

British Gasoline Shunting Locomotive. Description of a four-wheel gasoline locomotive used at the Kelso Yards of the North British Railway.

The engine is of 40 b.hp., water-cooled. The transmission comprises heavy roller chains driving each axle in combination with a Dixon-Abbott gear box providing two speeds in both directions. The engine is fitted with four spring plunger buffers and two central spring couplings. Otherwise the locomotive carries standard equipment. (*The Railway Gazette*, vol. 37, no. 1, July 7, 1922, p. 17, 2 figs., *d*)

Roller Bearing for Railway Rolling Stock. Description of a bearing recently tested on an English railroad. The bearing includes a series of rollers of particularly hard but not brittle steel, mounted in a chain-type carrier and arranged to run between two annular members, one surrounding the axle and the other fitted into the axle box.

The rollers are of the largest diameter permitted by the dimensions of the bearing to which they are applied, and are held in position axially by links of the pattern used for transmission roller chains. One link in each set is fitted with a spring fastener designed to permit disconnection if required in the course of maintenance. (*The Railway Gazette*, vol. 37, no. 7, Aug. 18, 1922, pp. 219, 2 figs., *d*)

Large Garratt Locomotive for South African Railways. Description of a 2-6-6-2-type Garratt locomotive, said to be the largest constructed on that system. It develops 50,000 lb. tractive effort and weighs 133.75 tons when in working order.

One of the principal advantages of the Garratt system is that the proportions of the boiler are practically unlimited, it being carried by a long girder frame unencumbered with tanks, etc., and away from the wheels. Its construction is on the simplest possible lines with large water spaces, while the copper stays, etc., are readily reached for inspection and repairs, the washing-out doors etc., being usually accessible. As there are no axles under the firebox, the latter can be made of any reasonable depth and volume desired, and this feature, combined with the moderate length of the tubes, has much to do with the excellent steaming qualities and economy in fuel obtained in actual service. The ashpan also is very accessible, as not only are the ends fitted with the usual air-admission doors, but each side has a large cleaning door or doors.

The weight distribution is naturally affected by the gradual consumption of the fuel and water, but as they constitute only a small proportion of the total weight of the engine, the variation of the adhesion weight on the wheels is not a serious problem. There is always sufficient adhesion for the tractive effort, and therefore the weights of the fuel and water only represent so much extra adhesion weight. This point should be clearly recognized.

In spite of there being 2554 sq. ft. of heating surface and a grate of 51.8 sq. ft. area, the boiler is built up of only six steel and three copper plates, all of which are of plain outline. This, of course, does not include the dome. (*Railway Gazette*, vol. 37, no. 4, July 28, 1922, pp. 126–217, 2 figs., *d*)

Gasoline Switching Locomotive with Hydraulic Drive

Gasoline Switching Locomotive with Hydraulic Drive. Description of a Canadian locomotive in which the power transmission and speed control are effected by a Waterbury (Waterbury Tool Co., Waterbury, Conn.) hydraulic variable-speed gear which gives any speed from zero to the maximum in either direction without steps and gradations and without varying the speed or direction of rotation of the engine.

Neither shift gears nor electric transmission are entirely satisfactory for use on railroad equipment with internal-combustion engines, partly because of their complicated nature (electric transmission) or lack of flexibility (shift gears). The Waterbury variable-speed gear consists of an oil pump designated as the A-end and a hydraulic motor designated as the B-end.

The construction of the gear is shown in Fig. 8. The driven shaft of the A-end, which receives the power from the gasoline engine, is shown at the extreme right-hand side, while the driving shaft of the B-end is at the extreme left. A cylinder barrel (27) is keyed to the inner end of each shaft. Each barrel has nine cylinders parallel to the shaft and fitted with pistons. When the barrels revolve, their inner faces slide on the valve plates (53), each of which has two ports, the ports in A-end being connected to those in the B-end by piping. The cylinder ports in the barrel faces register with semi-annular passages or ports in the valve plates, except at the bridges at the top and bottom of the plates. The connecting rods have one end secured in the piston and the other in the socket ring (35). The socket rings are connected by universal joints with the shaft so that while they revolve with the shaft their planes of revolution may be at any angle with the shaft provided by the setting of the roller bearings on which the socket rings revolve.

In the B-end of the gear the socket ring runs in an angle box secured in the end of the case and making a fixed angle of 20 deg. with the shaft. Thus as the shaft, the barrel, and socket ring revolve in the B-end, the pistons will have a reciprocating motion with a constant stroke. In the A-end the angle box is hung on trunnions and may be adjusted to any desired angle while the gear is running by means of the control shaft. If the angle box in the A-end stands in the neutral position at right angles to the shaft, the pistons are carried around with the cylinder barrels but have no reciprocating motion. No oil is therefore taken from or delivered to the passages in the valve plates. If the tilting box is inclined by moving the control shaft, the pistons begin to reciprocate, the stroke depending on the angle between the socket and the axis of the shaft. Every cylinder during one half of the shaft's rotation is drawing in oil from one of the passages in the valve plate, which it carries over and delivers into the other passage during the next half of the shaft's rotation.

The oil from the A-end is forced into one of the passages of the valve plate of the B-end. The cylinders of the B-barrel in communication with this passage make room for the oil by sliding back from the valve plate, but they cannot do this without forcing their respective sockets in the socket rings farther from the valve plates. This can only be done by turning the socket ring as a whole in its inclined plane in the angle box. While the pistons facing the pressure passage of the B-valve plate are receding to make room for the incoming oil and so imparting rotation to the B-shaft, the pistons facing the no-pressure passage are moving toward the valve plate and delivering oil into the respective cylinders of the A-barrel. Since the receiving capacity of the B-cylinders

Fig. 8 Pump Unit (Right) and Motor Unit (Left) of the Waterbury Hydraulic Variable-Speed Gear on Gasoline Switching Locomotive of Universal Engineering Corporation

is constant and the delivery capacity of the A-cylinders is varied at will by turning the control shaft, the speed of the B-shaft is correspondingly varied. With the engine running at constant speed the speed of the B-end depends upon the angle which the socket ring in the A-end makes with the shaft, while the direction in which the B-end revolves is governed by the direction in which the socket ring in the A-end is removed from the neutral position.

The efficiency of this type of transmission is said to range from 68 per cent to 25 per cent at normal speed to 82 per cent at full speed, and the combined weight of pump and hydraulic motor is less than 25 lb. per horsepower transmitted.

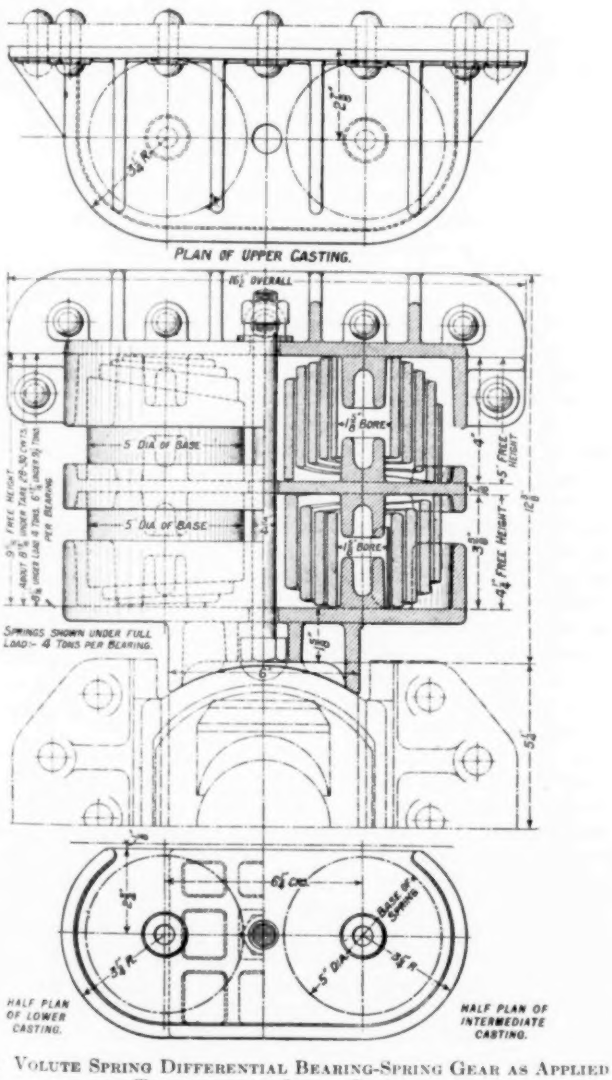

Fig. 9 Volute Spring Differential Bearing-Spring Gear as Applied to Tenders on an Indian Railroad

The control of speed and direction is effected by means of either of two handwheels placed in the driving compartment at each end, one man only being required to operate and control the locomotive, the speed of which is governed automatically by a hydraulically operated control gear which acts independently of the control shafts of the pump units as soon as the drawbar pull exceeds a predetermined amount.

In actual service the locomotive has shown great flexibility, which is of importance in switching service. The locomotive may be started under a dead load of any amount without overloading the engine, and three turns of the handwheel from the neutral position will bring the locomotive up to full speed.

In one trial the locomotive took three cars weighing 150 tons up a 4 per cent grade, stopping at the steepest point and starting again under full load without difficulty. Designs are under consideration for the application of hydraulic drive to passenger locomotives and high-capacity passenger cars. (*Railway Age*, vol. 73, no. 8, Aug. 19, 1922, pp. 323–326, 3 figs., *dA*)

Novel Differential Bearing-Spring Gear in Passenger Locomotive

Passenger Locomotive with Novel Differential Bearing-Spring Gear. Description of a 4-4-0-type meter-gage passenger locomotive recently rebuilt on an Indian railway. An interesting feature of the equipment of the engines is the bearing-spring arrangement on the tenders (known as the Herculo). As shown in Fig. 9, the springs are of the volute type, arranged in a group of four over each axle box, each group consisting of two upper and two lower springs in series. The upper springs are graduated to deflect under load at a greater ratio than the lower springs, thus insuring easy riding conditions irrespective of whether the tender is full or partly loaded. It is also said that breakage is reduced, as the total stroke is divided between the upper and lower springs; as the springs are reversely wound they have different periods and oscillation is stamped out.

An underhung differential spring gear has been employed on engine driving axles for several years on the same Indian railway and has been found quite satisfactory.

Volute springs of the same type have been used also in the engine, truck control. In this arrangement two springs are reversely wound and arranged right and left hand, which prevents hunting of the truck at high speeds and restores it quickly to a normal center when leaving a curve. It is claimed in the original article that this arrangement has materially reduced the wear of tire flanges. (*Railway Gazette*, vol. 37, no. 4, July 28, 1922, pp. 124–125, 5 figs., *d*)

REFRIGERATION

Refrigerating Machine with Centrifugal Compressor and New Low-Pressure Refrigerant

Carrier Refrigerating Machine. In air conditioning it is necessary to apply mechanical refrigeration to the cooling of water near its freezing point. Neither anhydrous ammonia nor carbon dioxide have proved to be entirely satisfactory, both because of their comparatively low efficiency and exacting conditions of operation, requiring, for example, an operating engineer in the case of the ammonia system.

Furthermore, the designers of air-conditioning apparatus have been looking for some refrigerating medium that could be worked in a centrifugal type of compressor direct-connected to an electric motor or steam turbine. For this purpose ammonia, owing to the large ratio of compression, low density, and high absolute pressure is unsuitable.

For centrifugal compression a vapor of high specific density, low ratio of compression, and low absolute compression is essential, and it is stated that such a medium has been developed, although its name and formula are not disclosed.

The centrifugal compressor for use in this new type of refrigerating machine is a horizontally disposed main shaft supported by two outside main bearings. The compressor has no valve and requires no lubrication, the conditions of operation being therefore similar to those in steam-turbine practice. Furthermore, an evaporator has been developed wherein the new low-pressure refrigerant evaporates without ebullition, leaving no film tension to be overcome, which is a very important feature when working under a vacuum.

Since the entire system operates under a vacuum, special provisions have had to be made to expel all the air entering the apparatus, this being done in this case by an oil seal.

In the new machine the flash system of operation is employed. Expansion valves are not required. A steam trap can be used for feeding the liquid, hence no skilled engineer is necessary for watching the feed. Even if the cooling water is shut off, no accident can happen.

During the test the steam turbine operated at 4000 r.p.m. with 120 lb. pressure, exhausting to the atmosphere; the rated output of the turbine was 119 hp. Only preliminary tests have so far been conducted on the new machine, and no performance data are therefore available at this time. The machine is rated at 100 tons refrigerating effect for air-conditioning work. It is not intended at present for cooling liquids below 32 deg. fahr. (*Ice and Refrigeration*, vol. 63, no. 1, July, 1922, pp. 43–45, 2 figs., *dA*)

SHIPBUILDING

Vane-Wheel Propulsion

Vane-Wheel Propulsion. Description of a new type of propulsion being tested out by Wm. Denny & Bros. at Dumbarton on a vessel recently built for the Irrawaddy Flotilla Co.

Vane-wheel propulsion is intended for use on shallow-draft vessels. Vane wheels are partly immersed wheels having their axes above water and substantially in the line of advance. They are fitted with propelling vanes over the immersible circumferential portion, the vanes having a pitch so that when the wheels are rotated they exert a forward thrust on the vessel.

In order to avoid steering effect, it is necessary to have two vane wheels of identical dimensions and symmetrically placed in relation to the hull of the ship. The pitch of the vanes of one wheel is right-handed and of the other left-handed. They are rotated in opposite directions, preferably outward at the top, so that the transverse thrust of each vane is balanced by that of the other, when they are driven at the same revolutions per minute, also the steering effect of each forward thrust moment is equal and opposite.

From recent experiments, both on models and full-sized ships, it would appear that vane wheels can be profitably applied not only to such shallow-draft vessels where screw propellers are unsuitable but even to deeper-draft vessels under certain conditions, the limiting consideration being the present uncertainty in regard to the ability of vane wheels to handle rough seas.

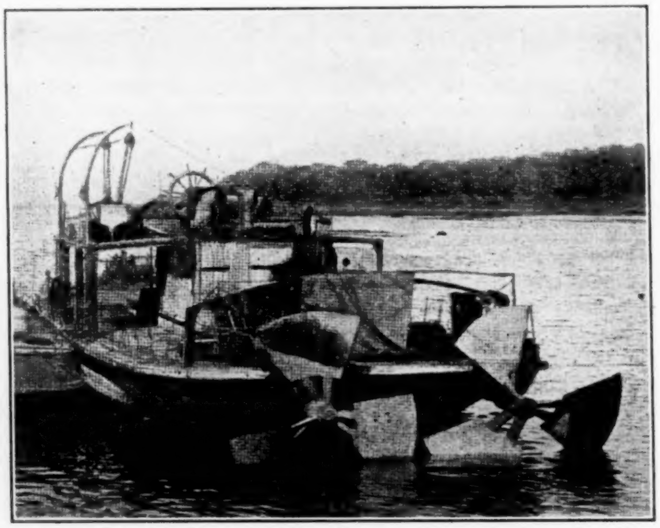

Fig. 10 Denny Bros. Experimental Vessel Fitted with Vane Wheels

The following are claimed as advantages of the vane wheel: High propulsive efficiency; on tests it has been found that vane wheels gave the same speed as twin screws (on the same vessel) with 41 per cent less shaft horsepower, in addition to which the use of vane wheels permits modifying to advantage the vessel lines and form; and great maneuvering powers, a vane wheel being capable of turning very rapidly about its own axis without advancing.

As a further advantage of vane wheels is cited the effective variation of water acted upon with variation of draft, and, therefore, variation of the thrust required. To a certain extent the same applies to side and stern paddle wheels, yet their propulsive efficiencies become considerably reduced with both overimmersion and underimmersion. In the case of vane wheels every portion of the immersed vanes is applied effectively at all drafts. The vane wheels permit of considerable variation of immersion, so that at the deeper drafts they have the advantage of acting efficiently on a greater sectional area of water, which keeps the revolutions per minute and slip for the same speed less variable in terms of draft variation than is the case with the other available methods of propulsion. In addition to this, it is claimed that vane wheels are stronger and lighter than either side paddle wheels or stern paddle wheels. (*Shipbuilding and Shipping Record*, vol. 20, no. 1, July 6, 1922, pp. 8, 9 and 19, *dA*)

Foettinger Transmission on a Liner

Foettinger Transformers on a Liner. Reference to the Foettinger transformer was made in *The Journal of The American Society of Mechanical Engineers* for February, 1914, on page 043.

The manner in which the transformer performs its maneuvering function may be briefly summed up as follows: The transformer consists essentially of an ahead and an astern "circuit," each of which is furnished with a primary wheel, guide blades and a secondary wheel, and, according to the direction of the ship, one or the other of these circuits is filled with water by the transformer pump, the water inlet and outlet being controlled by piston valves operated by a steam reversing engine. A tank is built into the framing of the ship beneath the transformer and serves to receive the water transferred during the operation of reversing, and also to accommodate any leakage water from the transformer glands. The transformer pumps, which are of the vertical type, are also placed over the tank and draw their supplies from it. In passing, it may be remarked that the turbine and transformer are separate, with an interposed thrust bearing, and are situated in different engine rooms separated by a watertight bulkhead. The reason of this arrangement is that the ship was designed shortly after the *Titanic* disaster, and special regulations were enforced regarding the watertight division of the hull. In nearly all other Foettinger installations the transformer has been built close up to the turbine, so that the prime mover and transformer together form a common unit, thus securing a close and compact grouping of the machinery. In this installation the turbine and transformer are tied together in a longitudinal direction, and are fixed to the framing of the ship in such a way that part of the thrust received by the transformer from the propeller and transmitted by it to the turbine is taken by the hull. Thrust bearings are fitted. The first transformer for this ship was completed and tested as early as 1913 at the Hamburg works of the Vulcan Company, and while the design in the main is unchanged, certain modifications have been made in the method of fastening the transformer rotors to the shafts, and in the design of the stuffing boxes, outlet channels, and cooling arrangements. At the points where the rotors project through the casing and through each other, and where the primary and secondary wheels project through each other, the peripheral surfaces are provided with brass rubbing rings, while the packing ring for the ahead primary wheel is lined with white metal.

In the present improved design of the maneuvering gear the operating of the necessary valves, both on the turbine and transformer, is carried out by means of a reversing engine, which also controls the transformer pumps which supply the water to the transformer circuits.

The steam circuit of each turbine contains an emergency stop valve which in certain circumstances is operated by the emergency gear and a shut-down piston valve which is moved by the reversing engine, while the main steam-supply valve and the overload nozzle valves may be operated by hand. Maneuvering is effected by (1) the main steam-supply valve, which regulates the supply of steam to the turbine; and (2) by the reversing engine, which controls the piston valves on the transformer, admitting water to the ahead or astern circuits as required. The reversing valves are positively connected to the shut-down piston valve, so that the supply of steam is completely cut off from the turbine before the reversing of the transformer begins. This is necessary, because when emptying the ahead circuit of the transformer, which is no longer required for the astern course, the primary rotor is only partly loaded, and if the steam were not shut off the turbine would race. The laps of the shut-down valve and those of the reversing valves of the transformer are so arranged that when the propeller shaft is being reversed in direction the following operations take place: The steam is at first shut off, the ahead circuit of the transformer is then emptied, and the astern circuit filled by the transformer pump. Then, when steam is again admitted to the turbine, the propeller shaft rotates in the opposite direction. The reversing engine is so designed that the first part of its stroke is passed through quickly and the second part more slowly, giving sufficient time between the closing of the steam valve and its reopening for the filling up of that circuit of the transformer which is coming into action. A hand pump is also provided for hand reversing.

The transformer pump, as will be seen from the section repro-

duced, consists of a vertical-type steam turbine carrying three Curtis-type wheels, the steam inlet being governed by a nozzle valve giving steam to the required nozzles. As previously mentioned, the two transformer pumps and the reserve pump are placed over the transformer tank, and the pumps draw from this tank and deliver to the transformer circuits. In addition to the transformer pump proper, there is on each pump an overflow pump which deals with the water flowing from the tank overflow and delivers any surplus water either at the feed tanks or overboard. The steam for the transformer pumps passes through the steam-supply valve, the strainer, and the emergency and regulating valves, and the supply valve is always completely open when the pump is working.

There is also an emergency stop gear used when the pressure of the transformer pump fails and the turbine is released from its load, and when the turbine exceeds its permitted maximum speed and causes the emergency governor to operate. This gear is fully described and illustrated in the original article. (*The Engineer*, vol. 134, no. 3471, July 7, 1922, pp. 4–5, 3 figs., beginning of a serial article, *d*)

Experiments on Contrary-Turning Coaxial Screw Propellers, Gen. G. Rota. Ship propulsion by means of double coaxial contrary-turning screw propellers has long been a matter of research. In this paper are given the results of tests made at the Spezia tank. The original article gives curves showing the thrust, turning force, and efficiency obtained with various arrangements of coaxial propellers.

The experiments indicate that the arrangement described may give an improvement in total propulsive efficiency of the order of 20 per cent or more, in addition to which there will be a gain by reason of the reduced resistance of the hull itself as a consequence of the suppression of brackets, bossings, etc.

The double contrary-turning coaxial screw propellers might also be suitable for submarines with the object of obtaining the simultaneous action of both motors, electric and Diesel, for increasing the speed on the surface. It is said that this might increase the speed from, say, 12 knots to 15 knots. (*Shipbuilding and Shipping Record*, vol. 20, no. 2, July 13, 1922, pp. 47 to 49, 7 figs., *e*)

SPECIAL PROCESSES

Truck-Wheel Manufacture from I-Beams

New Process of Manufacturing Truck Wheels. Description of the process and equipment developed by the Bethlehem Steel Co. for production of wheels from rolled steel I-beams.

The wheel is of the spoked type and is punched and formed from an I-beam in such a manner that the spokes and felloe are integral, the spokes being formed from the web of the beam and the felloe from the flange. The ends of the felloe are brought into contact and electrically welded, while the spoke ends are so shaped as to "keystone" together on each side of a hub spacer.

The I-beam used in the production of this wheel has wider flanges than usual, namely, for a $3^1/_2$-ton truck the flange is 10 in. wide.

The process is essentially as follows: First, holes are punched in the I-beam starting the outline of the spokes, this being done on a single-acting straight-side punch equipped with an indexing device for insuring proper spacing of the holes. The beam passes next through a coining press and die by which the sharp edges are rounded.

In the second blanking operation the outlining of the spokes is finished and the beam is cut in half longitudinally, producing two similar wheel structures, each of which ends as a complete wheel. Each of the wheel structures is then run through a press where the spokes are staggered, and, by this, spread apart at their hub ends, so that when the beam is formed to circular shape the openings left between the spokes accommodate the hub spacer. The same die which staggers the spokes also grooves them.

The forming of the wheel member to circular shape is the next stage. This is done in two operations. In the first, the ends of the beam are rounded to the shape of a quarter-circle. Before the second forming operation is started the hub spacer must be inserted between the inner and outer rows of spokes. With the hub spacer in position the wheel is bent by the second forming operation to circular shape. The press in which this operation is performed is rather unusual in size, being 118 in. between housings and having a die space of 72 in. and a stroke of 36 in. (*Automotive Industries*, vol. 47, no. 6, Aug. 10, 1922, pp. 270–273, 23 figs., *d*)

Fiber and Paper Manufacture from Reeds

Reed-Products Industry. Reeds or hydrophytes are plants of the hard kind of hydroflora, such as plain reeds, reed mace and the various kinds of rushes. They belong to the true *graminaceae* and have a stalk consisting of tubes and knots exactly similar to those of straw.

The analysis of hydrophytes shows a very high percentage of reed fiber (37 per cent), reed endosperm (9 per cent) and extractive matter containing sugar and starch (37 per cent). In addition, the root of the reed contains, roughly, 30 per cent of fiber and close to 40 per cent of extractive matter, about a quarter of which is reed sugar.

Reeds (which are here used as the generic name for all hydrophytes) contain a wealth of utilizable matter. The upper parts properly handled constitute an excellent food for cattle and were extensively used by the military authorities during the war under the name of "fragmit." The fibers of the upper reed resemble the fiber of straw and show remarkable strength.

The root fiber is particularly easy to obtain unbroken. It must be freed from the starch of the inner root and the incrustations of the outer layer of the root. But this can be done without applying expensive chemicals by the employment of a certain bacterium known as *bacillus fibrogenes Branco*. The decomposing effect of retting of the fibers by this bacterium is exceedingly vigorous, and all parts of the plant with the exception of the fibers are completely destroyed. Furthermore, the cultivation of the bacteria is very simple, a certain kind of reeds forming a good medium for this purpose. The retting is not a true decay; it begins about five to six days after the introduction of the bacteria and proceeds as a liquefaction of all the incrustations. After the roots have been treated in this way the fibers can be extracted clean and pure by simply washing the substance and without using any kind of chemical. The fiber obtained by this process of decomposition is very tough and suitable for textile purposes. The fiber of the outer layer of the root can be compared to finely separated fiber or flax, while the fiber of the core of the root represents a typical fiber that can be worked like hemp.

Practical experiments carried out on a working scale by a paper mill in central Germany have also shown that from reeds can be obtained cellulose well adapted to the manufacture of paper and cardboard. In this process the raw material is cut up into bits of 1 cm. (0.4 in.) length in an ordinary high-speed chaff-cutting machine. This chaff is fed to a beater in which leaves and parts of the plant adhering to each other are separated and the dust is extracted by an exhausting apparatus. The material is next soaked by sprinkling in large brickwork reservoirs and then boiled by means of steam. It is then ready to be worked into hard cardboard after a short treatment in a cylinder engine and without preliminary grinding, all intermediate treatment in edge mills and the like being completely eliminated. Hard cardboard does not need high-pressure treatment and has great elasticity. Unbleached cellulose from reeds is used for making all kinds of wrapping and packing papers, besides cardboards and pasteboards of various qualities, while bleached hydrophyte cellulose serves for making paper for newspapers and other printed matter, bleached cellulose also being mixed with other kinds of semi-finished cellulose such as wood cellulose, lignine and waste paper.

It is pointed out in the original article that the reed-product industry is of great importance from the point of view of world economy, partly as a source of supply of fodder, but chiefly as a means of reducing the enormous consumption of timber for paper manufacture; particularly as, according to the claim of the original article, there is actually no wood suitable for making paper in the whole of the huge stretch from 45 deg. latitude North down to the most southerly end of the continents, while reeds of a suitable character grow luxuriously in that very wood-poor area. (*Engineering Progress*, vol. 3, no. 8, Aug., 1922, pp. 181–184, 5 figs., *gA*)

STEAM ENGINEERING

Danish One-Cylinder Pass-Out Engine

Atlas One-Cylinder Pass-Out Engine. Description of an engine developed by the Atlas Company of Copenhagen, Denmark, for working economically in plants where a large heating demand exists in comparison with the power requirements.

In many industries, such as, for example, breweries, dyeing plants, etc., the proportion of power required is small compared with the steam needed for heating, and this latter is often demanded at two different pressures. In large plants of this character the pass-out steam turbine proved to be quite successful. The Atlas engine with its big valve gear is intended to solve the same problem for smaller plants.

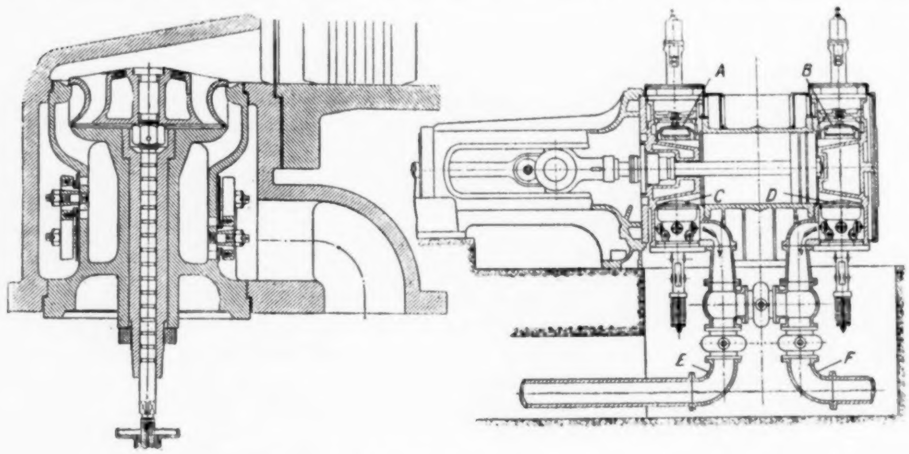

Fig. 11 Section Through Engine Cylinder of an Atlas Pass-Out Engine

The object of designing a pass-out engine is to attain maximum economy of operation by so balancing the load on the two sides of the piston that, on the one side, only the exact quantity of steam required for heating is admitted to the cylinder and exhausted to the condenser or a second heating system.

Fig. 11 reproduces a section through the engine cylinder and a detailed drawing of the arrangement of the automatic exit valves. The valves are accommodated in separate end covers, while the cylinder has a plain casting. Steam is admitted through inlet valves *A* and *B*, and is discharged through the exhaust valves *C* and *D* to the heating mains *E* and *F*. If the engine is fitted for condensing, a simple jet condenser is usually employed, with the air pump driven from the main crankshaft. Control and isolating valves are provided, and the exhaust-steam connection to the condenser may be taken from pipe *E*. The general disposition of the valve gear is indicated in Fig. 12. Double-seated drop valves are employed, and they are operated in the usual manner by eccentrics on the horizontal lay shaft. The cut-off is regulated by the speed governor, which controls the opening of the inlet valve, alternating the position of a curved lever which moves between rollers, and is attached to the eccentric rod. In addition to controlling the speed of the engine, it is also desired to balance the exhaust steam and power loads, and this is done by turning to account the variation of steam pressure in the heating mains, which variation is used independently to control and to alter the cut-off in that half of the cylinder which is dealing with the heating system. Thus, when a sudden demand for exhaust steam reduces the pressure in the heating main, the cut-off in one half of the cylinder is automatically lengthened, thereby admitting more steam, but at the same time the cut-off is reduced in the other half of the cylinder, and the balance is thereby maintained. Adjustment may be effected either by hand or by means of a special governor, which is directly controlled by the variation in pressure in the heating system.

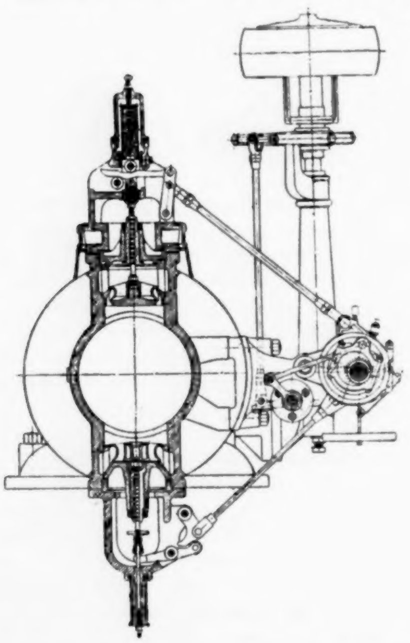
Fig. 12 Valve Gear of the Atlas Pass-Out Engine

The governing gear with hand adjustment for a single-cylinder engine is described in detail and illustrated in the original article. This part has to be omitted here because of lack of space.

The maximum back pressure against which a pass-out engine is capable of working is fixed by the initial steam pressure, and engines are generally built for back pressures varying from 5 to 50 lb. per sq. in. For a back pressure of 50 lb. per sq. in., an initial pressure of 160 to 170 lb. per sq. in. is required. The steam consumption varies according to the size of the engine and the conditions under which it has to work. The original article gives data of the test of a 280-i.hp. single-cylinder engine (19.75 in. bore, 27.5 in. stroke, running at 150 r.p.m.), the mechanical efficiencies being 92 per cent at full load, 89 per cent at three-quarter load, and 84 per cent at half load. (*Power House*, vol. 15, no. 13, July 5, 1922, pp. 26–28, 8 figs., *d*)

TESTING AND MEASUREMENTS

The Ball Hardness Tests, Doctor Moore. The author points out that the stresses developed in a specimen when a ball is forced into its surface are neither simple nor uniform. The ball hardness test is not capable of determining elementary and fundamental properties of a material and the indentation hardness as determined by the ball hardness test cannot claim to be regarded as a fundamental property. The test is purely empirical and valuable because of its practical utility. A numerical measure of hardness given by any indentation test should always be qualified by an indication of the type of test, which is the reason why we speak of Brinell hardness number. The value and meaning of the number depend upon the relations established by purely empirical methods between the hardness number and either behavior in service or other more fundamental properties.

Brinell first expressed the results obtained by the test as mean pressure per unit area; that is, as a stress. He found that the mean load per unit area increased considerably as the load was increased with the same size of ball, which was due to the fact that as the ball is forced into the material the deformation does not remain geometrically similar and the depth of the impression increases more rapidly than the diameter.

The more intense deformation produces greater strain hardening and a deep impression will carry a greater load per unit area than a shallow impression. To compensate for this effect Brinell then adopted as the hardness number the load divided by the spherical area of the impression. Though there is no rational basis for this method of impression, the Brinell hardness number

is firmly established as the accepted method. Although expressed in stress units, it is not a stress or a mean stress but a purely empirical figure derived by an arbitrary method.

The ball hardness test is applicable only to materials capable of deforming permanently under stress, that is, to materials possessing some slight degree of ductility, using this term in a wide sense. There are few metallic materials which are so brittle that a ball hardness test cannot be made on them. The range of hardness throughout which the test may be applied is very wide. There is no low limit; tests may usefully be made on lead with a Brinell hardness number over 700, the limit being somewhere in the neighborhood of 750. This may be due to the fact that as the steel ball has about this hardness, it cannot indent harder materials. Another possible explanation is that no permanent deformation can be produced in harder materials without fracture.

As regards the volume of the material to which the stress is applied, the range is very wide. At Woolwich the diameter of ball in regular use for the test ranges from 0.8 mm. to 10 mm. and a ball of 25 mm. diameter has been used. The volume of material stressed in a test varies with the cube of the ball diameter and the range mentioned is about 1 to 30,000 in volume tested.

Among other things, it has been found that, under certain conditions, a thin layer on the surface (resulting from machining, in particular planing with a shaping tool) may be harder than the rest of the specimen. This extra hardness extends, however, only to a depth of a small fraction of a millimeter. Soft metals (copper, aluminum, soft brass) are the most liable to harden on the surface when they are machined. Grinding, if properly carried out, rarely, if ever, produces this surface-hardening effect. Polishing causes a flow which is too shallow to affect appreciably the ball hardness test.

As regards the influence of the size of ball or load on the ball on the Brinell number, the author cites Meyer's second law, which he expresses in one formula and then proceeds to the discussion of the physical meaning of these laws. The Brinell hardness machine is described and illustrated. (Paper read before the London Local Section of the Institute of Metals, abstracted through *The Metal Industry*, vol. 20, no. 22, June 2, 1922, pp. 510–513, 1 fig., *dt*)

Tearing Tests of Metals

Tearing Tests on Metals, Henry L. Heathcote and T. G. Whinfrey. In impact tests, test pieces which may have given good results under the tensile test sometimes break like a carrot. It is not at all easy to break a carrot until the periphery has given way, when it tears across quite easily. The present authors have investigated this tearing and tests have shown that the tearing strength of a metal is very much inferior to the tensile strength, and of the order of about one-fifth of the latter.

Test pieces for tearing tests have to be cut from thin sheets. The form recommended is made by taking a piece of sheet about 2 in. by 4 in. in area and slitting it carefully with tinners' snips, as shown in Fig. 13, *a*. The tongue of the metal 1 in. by 3 in. is turned square out in front with the two wings exactly opposite in direction as shown at *b* on the right-hand side of the figure. This bent test piece is then mounted in a tension machine capable of registering accurately loads of a few pounds. A machine for testing paper or fabric is usually suitable. Pull is then gradually applied until the metal tears, as may be observed under a strong glass.

The pull observed is that required to tear the metal in two places and bend and unbend a total width equal to that of the specimen. In order to eliminate the work done in bending, it is necessary only to execute a similar test on a narrower or wider test piece cut from the same material.

If P is the pull required to tear, bend, and unbend a piece x in. wide, and p the pull required to tear, bend, and unbend a piece y in. wide, then $P - p$ is the pull required to bend a portion of the piece $2x - 2y$ in. wide. Therefore—

$$\text{Pull required to bend piece } 2x \text{ in. wide} = \frac{P - p}{(2x - 2y)} \times 2x = \frac{(P - p)\,x}{x - y}$$

$$\text{Pull required to tear specimen in two places} = P - \frac{(P - p)x}{x - y} = \frac{px - Py}{x - y}$$

$$\text{Tearing force per linear inch} = \frac{px - Py}{2t(x - y)}$$

where t is the thickness of the sheet.

It is apparent that the force required for bending will quite overshadow the force required for tearing in a thick piece.

It is believed that tearing tests will bring out valuable information regarding the stability of the metals tested for construction purposes, and also be of interest in connection with the investigation of the microstructure of metals and alloys.

From the appearance of the fractures which occur during the life of metals in use, it is obvious that they are for the most part tear fractures, or, as they are more commonly called, "fatigue fractures." Indeed, "fatigue fractures" doubtless start from some internal notch where the stress concentration is above the ultimate strength of the material. Probably all hardened steels break by tearing, as also do high-tensile alloy steels such as nickel-chromium steel.

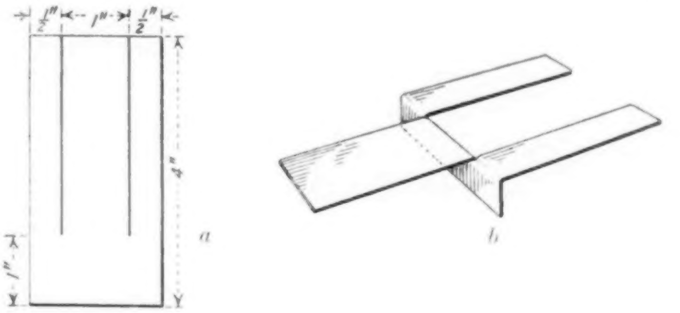

Fig. 13 Test Piece for Tearing Testing (1, Before Bending; 2, After Bending)

On the other hand, it would not do to assume that resistance to tearing should always be as high as it is possible to make it. When material is machined, the ease with which it is removed by the tool depends upon the ease with which it tears apart forward of the tool point; and a high machining speed will be obtained only when the Brinell hardness and resistance to tearing are relatively low. (*Chemical and Metallurgical Engineering*, vol. 27, no. 7, Aug. 16, 1922, pp. 310–311, *eA*)

Determining the Impact Loads on Track Bolts. Data of tests recently carried out on the Philadelphia & Reading Railway to determine the stresses in track bolts induced by the impact of trains and locomotives and the pull of a trackman on a wrench. A separate test was also made to learn the breaking strength of a track bolt and carried out under the same conditions. The load caused by the impact was measured by an adaptation of the Brinell system of testing hardness, the impact or pull of the wrench forming depressions in hardened steel washers, from which the stresses were determined.

The principle of the method consisted of the forming of impressions on hardened steel washers, through the medium of standard Brinell balls, by the loads which it was desired to determine. The original article gives the method employed for calculating the actual loads.

The average minimum and maximum loads were 25,980 lb. and 29,298 lb., giving stresses on the 1-in. bolts used of 47,236 lb. per sq. in. and 53,270 lb. per sq. in., respectively. (*Railway Age*, vol. 73, no. 7, Aug. 12, 1922, pp. 277–278, 4 figs., *e*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A.S.M.E.

Research Résumé of the Month

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulas or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Cement and Other Building Materials A4-22. STORAGE AND TRANSPORTATION OF PORTLAND CEMENT. The cause of the deterioration of portland cement during storage and transportation and the means of preventing it, form the subject of an investigation recently conducted by the U. S. Bureau of Mines. This report was prepared by W. M. Myers, assistant mineral technologist, and is known as Serial No. 2377.

The material for this report was gathered from all available printed sources of information on this subject and from the leaders in the cement industry. It accordingly includes a full bibliography. Address H. Foster Bain, Director, U. S. Bureau of Mines, Washington, D. C.

Foundry Equipment, Materials and Methods A2-22. INCLUSIONS IN ALUMINUM-ALLOY SAND CASTINGS. In aluminum-alloy foundry parlance, metallic and non-metallic inclusions are termed "hard spots," and in aluminum-alloy sand castings and in die castings they are very troublesome. The inclusions differ so widely that the term "hard spots" is only roughly descriptive at best; in fact, it is exceedingly undesirable, and should not be accepted in the nomenclature of metallography. However, because it has been in common usage for such a long time, it is used in U. S. Bureau of Mines Technical Paper No. 290 to include all kinds of metallic and non-metallic inclusions that cause difficulty in polishing and machining aluminum-alloy castings. Hard spots in aluminum-alloy sand castings are well known to founders, and certain kinds of hard spots are frequently found in aluminum-base die castings.

Although many representative aluminum-alloy founders by care in practice have been able practically to eliminate hard spots and resulting trouble when aluminum-alloy castings are machined, others still have periodic difficulties because of this defect. A number of foundrymen have suggested at various times that the Bureau of Mines investigate hard spots, put the available information on record, and suggest preventive methods. Such an investigation was undertaken and carried out in connection with the Bureau's work on casting losses in aluminum-alloy foundry practice. The present paper is published as a contribution to the literature of aluminum-foundry practice and as a guide to founders in preventing scrap losses from hard spots in castings. Address the Bureau of Mines, Washington, D. C.

Highways A1-22. FLEXURAL STRENGTH OF PLAIN CONCRETE. See *Cement and Other Building Materials A4-22.*

Iron and Steel A4-22. STUDY OF ALLOY STEELS. The results of studies in the experimental production of certain alloy steels are given in Bulletin 199, by H. W. Gillett, chief alloy chemist, and E. L. Mack, assistant alloy chemist, which has just been published by the U. S. Bureau of Mines.

The production of small heats of alloy steels on an experimental scale is often desirable in beginning the study of new alloy steels before large amounts of expensive alloys are used in heats of commercial size. Such small heats can sometimes be made up at crucible-steel plants but few crucible-steel makers care to undertake experimental heats for other firms. Small electric furnaces offer some advantages over crucible furnaces for experimental work, and various types of such furnaces are being successfully used by different firms for such work.

The Bureau of Mines has recently made up experimental heats of alloy steels for the Army and the Navy. The steels for the Army were desired for work on gun erosion, especially as regards the effect of nitrogen on the steel. The request from the War Department for this experimental work was made during the course of the World War and followed the receipt of information from a creditable source that Germany was using uranium steel in the liners of some high-power naval guns. It was stated that uranium stiffens steel at high temperatures, and raises the softening point some 200 deg. cent., so that gun erosion at the end of the Jutland naval engagement was ascribed to the uranium-steel gun liners. Somewhat similar reports had been received as to the use of molybdenum steel.

The ingots made for the Navy were in two series, the first being rolled, heat-treated, and given physical tests by the Bureau of Standards. The second series was made in larger ingots, which were rolled into plates, cut up into smaller plates, and heat-treated to different Brinell hardness numbers by the Halcomb Steel Co. Physical tests of this series under several heat treatments are being made by the Navy.

Some of the points brought out in preparing the steels, particularly as to the recovery of the alloying elements from the various ferroalloys entering the steel, may be of interest and are therefore put on record at this time. The indirect-arc furnace finally used seems also to justify its description.

Detailed information regarding tests made with uranium, silicon, manganese, molybdenum, chromium, vanadium, nickel, copper-nickel, aluminum, zirconium, cerium and boron as alloying agents are given in Bulletin 199, which may be obtained by addressing the Bureau of Mines, Washington, D. C.

B—Research in Progress

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for coöperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Iron and Steel B4-22. MOLYBDENUM AND OTHER ALLOY STEELS. In the study of molybdenum and other alloy steels being made by Dr. H. W. Gillett at the Ithaca, N. Y., office of the Bureau of Mines, 600 endurance test pieces have been ground and polished to a special mirror finish ready for testing. These bars will keep two endurance machines busy night and day for probably more than a year.

Paints, Varnishes and Resins B3-22. FAILURE OF PAINT AND VARNISH ON EXPOSURE TO WEATHER. During the recent meeting of the American Society for Testing Materials at Atlantic City, there was an extended informal discussion of the mechanism of failure of paint and varnish films on exposure to the weather. One party to the discussion claimed that a paint or varnish film should contain moisture in order to retain its elasticity. The known beneficial effect of baking a varnish film was then cited as being contradictory to this theory that moisture improved the durability of paint or varnish. The importance of the problem makes it appear advisable to study baked varnish films in order to obtain some definite data on the effect of baking. The Bureau of Standards has commenced an investigation in which a series of spar varnishes of varying lengths of oils will be baked on tin panels at different temperatures, and then tested for durability when exposed to the weather.

Steel, Its Treatment and Products B5-22. MINE-DRILL STEEL. A committee, advisory to the U. S. Bureau of Mines and Bureau of Standards, has been formed on the subject of mining-drill steels, their composition, treatment, thermal and mechanical, and reclamation; together with causes of breakage as related to standardization of design and practice, properties, manufacture and preparation, with the object of eliminating waste and delays in mining operations. Several meetings have been held, a preliminary program mapped out, and these Bureaus have made a joint survey of drill-steel practice in the metal mines of some ten western states, obtaining data which will be of use in suggestions as to standardization of design, heat treatment and practice generally as relating to drills and auxiliary mining machinery. Reports of this survey are in preparation.

E—Research Personnel

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

Iron and Steel E1-22. THE BRITISH CAST IRON RESEARCH ASSOCIATION. A pamphlet just received describes the objects of this recently organized association as (1) to promote coöperation among firms engaged in the various allied industries connected with the production and utilization of cast iron in Great Britain, with a view to the establishment of a scheme for scientific and industrial research; (2) the distribution among its members of technical and other information relating to the production, treatment, manufacture and utilization of cast iron. This necessitates the efficient coördination of the existing means of research and their further development.

The work of the Association will include the investigation of problems arising in the manufacture of pig irons, gray-iron castings, malleable-iron castings, semi-steel castings, chilled rolls, cast-iron hollow-ware, cast-iron pipes, light castings, etc., in such a way as to cover and include all branches of the cast-iron industry. Successful and economic production of these materials is very intimately bound up with the questions of melting, annealing, furnace design and construction, refractory materials, molding sands, the economical utilization of fuel, and the engineering aspect of foundry work. All these and other subsidiary operations will be dealt with by the Association, either directly, or in collaboration with other research bodies.

For further information address Mr. H. B. Weeks, F.I.C., care of Vickers, Ltd., Barrow-in-Furness, England.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Department of MECHANICAL ENGINEERING are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities and policies of the Society in Research and Standardization.

The Accuracy of Boiler Tests

TO THE EDITOR:

The writer desires to express his gratification that the main object of his Spring Meeting paper on The Accuracy of Boiler Tests has been so amply fulfilled by the masterly discussion of leading authorities. This discussion has been so thorough that it is impossible to reply to it fully without writing another paper.

Replying to Mr. Bell, the writer prefers to have all test reports accompanied by heat balances. They indicate the value of the reports. Serious unbalance shows inefficiency of observation or of operation. Reports of a series of tests wherein the "unaccounted for" was consistently over 20 per cent were recently submitted to the writer, who had reason to believe that much more coal was leaving the fire in a non-gaseous state than was proper and than the ash analysis suggested.

The value of the heat balance as a statement of what has happened to the heat is really not open to question. But many engineers who are not skilled in boiler testing are impressed with the heat balance; and the writer therefore feels justified in repeating that it is not a *balance* and that it adds nothing to the accuracy of the test. It is usually less of a check on the efficiency than on the other items.

The writer appreciates Mr. Bradshaw's remarks on the determination of dust in blast-furnace gas, and its similarity to the determination of water dust in steam. That the velocity of the gas sample entering the tube should be the same as that of the bulk agrees with the writer's views; as also does the use of a sampling tube pointing upstream.

Mr. Burke suggests using the draft loss through the fuel bed to determine the condition of the fire at start and stop. This is a step in the right direction; but the presence of clinker must be reckoned with, and variation in the size of coal in some cases, as these would increase the draft loss for the same amount of fuel in the bed.

His caution about the rate of feed at start and stop is very important. It is probable that many engineers would be surprised at the error which can result in this way. It is more accurate to calculate the deficiency at the end of the run than to pump rapidly up to the mark as the test is coming to an end.

The importance of having conditions as well as quantities the same at both ends of the trial cannot be stressed too much.

The difficulty of getting even an approximate idea of the proportion of fuel sent to the ashpit may be the cause of considerable error in the heat balance, as has also been pointed out by Mr. Bell.

It is questionable whether it would be agreeable to rate all superheaters at 10 sq. ft. to the horsepower. Should Mr. Bell's Radiant Heat Absorption Superheater be rated at this figure?

Replying to Mr. Davidson, it cannot be too strongly urged that the present method of reporting boiler tests is not strictly honest. It is not even sufficient to say that the power used by auxiliaries should be noted and that any one interested can find the net efficiency, or that conscientious engineers always instruct their clients to pay no attention to the efficiencies they have reported. If a test report does not openly show the net efficiency, it is not a straightforward report. It may be that a simple system does not show as high an efficiency as a more elaborate one, while the more elaborate one loses more than the apparent gain by the power required to operate it. Both efficiencies should be clearly shown thus:

	Simple System	Elaborate System
Gross efficiency	75.0	79.0
Net efficiency after deducting power consumed by parasites	74.0	72.0

We then clearly see that the more elaborate system is more efficient in combustion, heat transfer or what not; but that in the final analysis the simpler system is the more economical. It is to be hoped that the new Boiler Test Code will prescribe a form of report in which these facts are not obscured.

Replying to Mr. Funk, the writer's reasoning on the reliability of steam sampling is based very largely on experience with other apparatus. Experimental investigation is highly desirable.

Messrs. Hirshfeld, Berry, Thompson, and Carter have done a valuable work in pointing out that many lawsuits have followed this false conception of accuracy. These would be avoided by our admitting that we cannot guarantee the accuracy of boiler trials to be within some given percentage, and then setting definite tolerances to be allowed. This naturally refers to commercial tests. Research tests have little or nothing to do with guarantees, and nothing to do with lawsuits.

Research tests are made at home, so to speak, and under conditions which cannot usually be duplicated profitably with commercial tests. The writer believes that when these gentlemen, who have devised and frequently operate highly developed testing methods and means in the same plants, place the accuracy of these precision tests at about plus or minus 1.5 per cent, they virtually confirm the writer's proposed allowance of plus or minus 3 per cent on a commercial test. He does not believe it is generally recognized that such research tests may be out 1 per cent.

There is another kind of research test, the kind made by the ambitious engineer of the small plant, without much apparatus or abstruse knowledge. The writer recently saw a case where such an engineer had raised the "actual" evaporation per pound of coal "as fired" about 15 per cent as averaged from a large number of tests. These tests were scarcely worth the name and probably carried large errors, but the fact remains that his employer is buying less coal than he used to.

The use of the boiler as a gas-flow meter in connection with the pressure drop through the fuel bed is excellent in checking the thickness of the fuel bed, and may reduce this error very materially.

The writer did not in his Par. 17 refer to drying the coal *to be fired*, but to drying samples to ascertain the moisture while the test was in progress.

He entirely agrees with Mr. Kreisinger that the really important thing is not a single test, but a load-efficiency curve, drawn through a group or groups of tests. The accuracy of such a curve may easily be within 1 per cent. But such multiple testing is not always possible with commercial trials.

To emphasize the care necessary in taking samples, it may be well to mention that the coal analyzed in the laboratory is of the order of 1/10,000,000 of the coal burned and that about 1/100,000,000 of the flue gases are analyzed. The serious feature of errors in the heating value of the fuel is that they are in no wise reduced by increasing the duration of the test. Unless the heating-value error can be made very small, a point is soon reached where little is gained by increasing the duration of the trial. Mr. Kreisinger's broad discussion on the reliability of the heating value is rendered the more authoritative by his long experience.

The writer feels prompted to add the following recent analyses of fuel oils:

	B.t.u. per Pound — Boiler test number		
Analyst	4	7	8
A	..	..	17,803
B	..	..	18,600
C	17,081	17,261	17,199
D	..	17,295	..
E	..	16,980	..
F	..	..	..
G	17,334	16,968	17,256

In test No. 4, analyst G is 1.48 per cent above analyst C, while in No. 7, C is 1.72 per cent above G. In No. 8 they agree very closely, but analyst B gets a result 2.35 per cent above C.

The "boiler horsepower" dies slowly. If we were to express the load in all future test reports as B.t.u. per sq. ft. of heating surface per hour as Mr. Kreisinger suggests, as well as in "percentage of rating," it is probable that we could become reconciled to the loss of the boiler hp. more quickly.

Mr. Moultrop mentions handhole leakage as one of the unknowables. The writer believes that during the trials made about 25 years ago by the British Admiralty to determine the relative merits of Belleville, Scotch and other boilers, the water loss in the Belleville ran about 5 per cent of the evaporation in some instances, but this is only from memory.

He does not agree with Mr. Moultrop that the manufacturer and customer should settle upon a tolerance. The first manufacturer who does this is very liable to be looked upon as having little faith in his own product. Such tolerances must be settled and recommended by the Boiler Test Code Committee if at all, and it is to be hoped that this will be done.

The writer is glad to find Mr. Tenney in agreement with him that all conditions surrounding the test should always be reported. This is not done very often, and some important conditions are scarcely ever reported. It is obvious that a certain efficiency attained with the coal Mr. Tenney burns might be much more creditable than a little higher efficiency with a much better coal.

In reply to Mr. Vennum, the present boiler efficiency shows what proportion of the heat in the fuel was used to make steam, but it is reasonable that an efficiency should also be reported which shows how much heat was used of that which it was possible to use. This proposed efficiency would be mainly for research purposes, not for commercial tests.

Mr. Vennum says that we want to know what proportion of the heat in the fuel is made available for mechanical use, and it is obvious that this is just what our present efficiency does *not* show us, until after we have deducted the auxiliaries.

Speaking generally, the discussion confirms the writer's opinion that the inaccuracies at present inherent in commercial boiler testing are sufficient to warrant the introduction of tolerance in the performances of guarantees as a recognized engineering custom. In research testing the errors can be reduced to about one-half of those of commercial tests, and to still less than this as the number of the tests is increased and rendered into a load-efficiency curve.

Alfred Cotton.

St. Louis, Mo.

Compounding the Combustion Engine

To the Editor:

Referring to the discussion of a paper by Mr. E. A. Sperry on Compounding the Combustion Engine which appeared in the August number of Mechanical Engineering, I would like to submit the following comments.

I have carefully followed the subject in question for some years and wish to say that while Mr. Sperry's contribution to the art should by no means be minimized, it should not be judged by the paper he presented nor by the extravagant claims and references he makes in his closure. The fact that he started considerable discussion of this promising subject among the engineers concerned, however, is evidence enough that he "is to be commended for his research along this line," as Mr. J. C. Shaw expressed it.

In his paper Mr. Sperry utterly disregarded established technical terminology and employed such expressions as "persisting" pressures, "hanging on to pressures," "chilled perimeter," "modern two-stage method of compression," etc. These may mean something to him, but they have been rightfully objected to by his commentators, Mr. J. C. Shaw at the meeting, and Mr. James Richardson in (London) *Engineering*.

If Mr. Sperry's "special adaptation of cushioning," meaning the compression of part of the exhaust gases trapped in the low-pressure cylinder (which he claims as new and which Diesel used on his compound engine in 1897), was adopted to restore them to a temperature equal to that of the gases coming from the high-pressure cylinder, then he stopped too soon when he equalized the pressures, because at that time there is of course still over 1000 deg. fahr. difference in favor of the incoming gases.

In his closure he proceeds to use the same misleading language: "The compound combustion cylinder handles a great many times the weight of air compared with the simple Diesel, not only many times the weight of air but many times the fuel with more complete combustion than in any simple engine." Later it develops that "a great many times" means "from four to six times," which is rather modest for such an ambiguous term, but the "more complete combustion" is left on the conscience of the inventor to prove.

I also question his assertion that a "compound engine of any kind" invariably develops back pressure on the piston" of the next higher stage. Steam engines do and Sperry's engine does, and that is the only thing that may make them akin; but, generally speaking, internal-combustion compounding and steam-engine compounding have nothing in common, not even back pressure, since that is avoidable in the combustion engine.

Mr. Sperry's discussion of reasons for using or not using a crosshead does not bear on the subject of compounding. However, he has only to visit the Brooklyn Navy Yard to see a 3000-hp. Diesel submarine engine of 21 in. bore without any crosshead in it.

His dismissal of "shocks, strains and heat troubles" as being "on a par with many other of the imaginary troubles," or his "there is no such thing as a previous compound engine to compare with," lead me to ask you to reprint for his information, as well as for that of many other engineers, the appended translation of Dr. Diesel's statement regarding his own efforts in compounding, published in 1913.

In conclusion, I would say that in spite of the defects of Mr. Sperry's paper, grave as they are, and the fact that he did not invent "compounding," he claims that he built an engine that runs economically, and that is an achievement well worth claiming.

Washington, D. C. E. C. Magdeburger.[1]

[The translation of Dr. Diesel's statement regarding his efforts in compounding, to which Mr. Magdeburger refers in his communication, immediately follows.—Editor.]

The Compound Engine[2]

The German patent D.R.P. 67,207 of February 28, 1892, contained a figure (Fig. 73) of the compound engine. From the text of this patent application the following is quoted:

"Compression of air as well as the expansion of the exhaust gases could be undertaken in steps, as in a representative construction shown in Fig. 73. In this sketch the valves are shown only schematically. The housing, the connecting rod, the flywheel, etc., are omitted. In such a construction two internal-combustion cylinders *C* are perfectly identical with the cylinder of any one-cylinder motor. These cylinders are connected by means of mechanically operated valves *B* on the two sides of one larger middle cylinder *B*; also mechanically operated valves *A* connect the internal-combustion cylinders with the air container *L*. The new process with this construction is as follows:

"Piston *Q* moving upward draws in atmospheric air through valve *d*, compresses it up to a certain pressure, and delivers it through valve *g* into the air container *L*. The lower part of the middle cylinder henceforth serves only as an air compressor to precompress the air necessary for combustion. At *g* are water-injection nozzles through which it is possible to inject water during the precompression. The cycle can be run with or without water injection. The cycle in the cylinders *C* is exactly the same as in the single-cylinder motor already shown, except that the piston *P* moving downward draws in the air not from the atmosphere but out of the air container *L* where the air is already under certain pressure. Moving upward the piston *P* completes the second stage of the compression up to a given pressure. Both dead-center positions of piston *P* are shown dotted and marked with figures 1 and 2. After that, piston *P* again goes downward with oil being injected continuously for a certain part of the stroke. In the position 3 of the piston the oil injection stops and the gases expand further. When the piston is in the lower position 1 the valves *b* open. The piston *Q* at that moment is exactly opposite since the cranks are 180 deg. apart. Continuing, piston *P* goes up and piston *Q* down, and further expansion of the exhaust gases up to the volume of the cylinder *B* takes place. After that the valve *b* closes and *p* opens, so that with the next upstroke of the piston *Q* the exhaust gases can be expelled into the atmosphere through valve *F*."

Already in my paper delivered in Kassel in June, 1897, I maintained that in a compound engine the thermodynamic efficiency will be very much higher than in a single-cylinder engine. The constructional drawings of such a compound engine were made to my order by Mr. Nadrowski, of

[1] Aide on Diesel Engines, Bureau of Engineering, Navy Department. Mem. Am.Soc.M.E.

[2] Translation of a chapter from a book by Dr. Rudolf Diesel, entitled The Development of the Diesel Engine (Die Entstehung des Diesel Motors), Julius Springer, Berlin, 1913.

Berlin, during the year 1894–1895. This engineer later came to Augsburg where he improved these drawings as the results from the single-cylinder engines had indicated. The first detail drawings for the frame and bedplate reached the pattern shop late in December, 1895. Inasmuch as the tests on the single-cylinder engines had been producing new results continuously, the building of a compound engine was not rushed. Several patterns were completed at the close of 1896, and it took another six months before the assembly could begin. My assistant, R. Pawlikowski, was entrusted with the supervision of the assembly and the conducting of tests which began in September, 1897. He was assisted in that work by Messrs. Böttcher and Reichenbach whenever these gentlemen were not otherwise employed.

The construction of details of the compound engine, as far as the internal-combustion cylinder is concerned, is exactly the same as that of the single-cylinder, and since the whole construction never attained practical importance, I do not think it of sufficient interest at this time to publish the detail drawings. However, Figs. 74 and 75 are photographic reproductions of both sides of this engine, and 76 shows it on the test stand next to the single-cylinder engine.

The dimensions of this engine were as follows: High-pressure cylinder bore, 200 mm.; low-pressure cylinder bore, 510 mm.; stroke for both cylinders, 400 mm.; connecting-rod diameter, 80 mm.; number of revolutions, 150 per minute.

The tests themselves can be now summarized. First of all they showed that the air in the intermediate container between the low-pressure and high-pressure cylinders cooled off too quickly, and a steam-heated coil was built in as shown in Fig. 77, following which at the end of September, 1897, the first ignitions took place. Fig. 78 shows the series of the first high-pressure diagrams. After that the air out of the low-pressure cylinder was taken to the high-pressure cylinder direct without first going through the intermediate air container. This showed the desired result and the heating coil for the precompressed air was done away with. After about eight minutes of running, good smokeless and regular ignitions in the high-pressure cylinder were produced without preheating of the air with steam. Preheating of the air or of the engine itself henceforth would be only necessary when starting similar to the preheating of the cylinders in steam engines.

Later the engine ran quite regularly, as shown by the diagram Fig. 79, which is a superimposition of 30 ignitions. Soon, however, different mistakes showed up on the engine: the high-pressure cylinders got very hot; the cooling water boiled; the uncooled piston knocked; the transfer valves warped, etc. We succeeded in overcoming these mistakes, and for hours the engine ran on no load without any mishap. The diagram, Fig. 80, is an example of this. Here the air out of the compressor cylinder was delivered direct into the high-pressure cylinder without going through the intermediate air container. The tests showed a considerable pressure drop at the point of transfer of the exhaust gases from the high-pressure into the low-pressure cylinder. To lessen this drop a part of the exhaust gases was trapped in the low-pressure cylinder and compressed up to 12 to 14 atmospheres, so that at the moment of opening of the transfer valve no drop in pressure could take place. This result was of course compensated for by a considerable negative work on the diagram. Fig. 81 in the upper right-hand corner, shows the average original diagrams taken on November 18, 1897. The average pressure of the compressor diagram (lower side of the low-pressure cylinder) was 2.40 kg. per sq. cm. The average pressure of the high-pressure cylinder to the right (the cylinder to the left was not in working order) was 19.4 kg. per sq. cm. The average pressure of the low-pressure cylinder was 2.74 kg. per sq. cm.

The main diagram shows the above-mentioned diagrams Rankinized, the lower part showing the details of actual construction of the diagram. In the table to the left the final results are given whereby all average pressures are referred to the upper part of the low-pressure cylinder to compare it directly with the results of a single-cylinder motor of similar dimensions. The process of figuring can be easily checked with the dimensions of the engine cylinders as given above.

The original diagrams in this manner give an average pressure of 4.39 kg. per sq. cm. The Rankinized diagram gives an average pressure of 4.48 kg., that is, only two per cent higher, hence an error of only two per cent. In this main diagram an ideal diagram is also shown which could be produced in the middle cylinder alone when precompression and after-expansion would not be employed, and that comparison shows the most disappointing result, namely, that in a compound engine only 54.1 per cent of the ideal diagram was converted into useful work.

The test results showed a no-load fuel consumption of 499 grams per horsepower-hour, which quite explains the inefficiency of the diagram.

The most important loss of the whole process is the heat loss through the transfer of the exhaust gases from the high-pressure into the low-pressure cylinder. At this point, as it is shown on Fig. 73 schematically, there was not a single transfer valve but two valves, one close to the high-pressure cylinder and the other close to the low-pressure cylinder, in order to isolate the considerable volume between those two cylinders from the cylinder volumes proper. These two valves were cooled and the heat absorbed by the cooling water of the valves could be measured very accurately. This heat loss to the cooling water of the valve amounted on one side of the engine to 5.9 per cent of the total available heat of the oil, and on both sides, therefore, to 11.8 per cent, or about half of the heat that was transferred into useful work in a single-cylinder engine. Each of these four valves absorbed about three per cent in round figures of the total available heat. How much heat was lost at the same time to the cooled walls of the transfer ducts themselves and how much besides was taken away by radiation, could not be definitely measured. However, it must be assumed that these losses were considerable, due to the fact that the surfaces of the ducts were large and were energetically cooled. These enormous losses could not be brought into harmony with the computed results of the heat transferred through walls according to the prevailing methods at that time. Quite naturally an effort was made to estimate beforehand these losses based on the prevailing assumptions of the coefficient of heat transfer, but these computations produced such small values for these losses that I did not worry about them. Zeuner, with whom I discussed this point long before the actual tests were conducted, did tell me that in his opinion considerable surprises might be expected with gases at such high velocities, but that was only a matter of opinion that he could not substantiate with figures. The results proved that these computations were a failure. This single loss was so great that practical application of compounding could not be thought of for this reason alone. In view of this fact it is probably superfluous to describe the other numerous losses encountered in tests which were due to the transfer of air out of one cylinder into the other both during its compression and expansion. The total losses doomed the compound principle. My great hopes to considerably improve the heat utilization of the single-cylinder engine had to be given up, however much I disliked to do it.

The above brief description of these tests and the scientific explanation of their failure will, I hope, save others from similar disappointments.

Second Revision of A.S.M.E. Boiler Code, 1922

A HEARING is held by the Boiler Code Committee at least once in four years, at which all interested parties may be heard, in order that such revisions may be made as are found to be desirable, as the state of the art advances. The year 1922 becomes the period of the second revision, the first revised edition of the Boiler Code having been issued in 1918. The Boiler Code Committee plans to hold a Public Hearing in connection with the next Annual Meeting of the Society in December, 1922, to which the membership of the Society and everyone interested in the steam-boiler industry will be invited and where they may present their views.

In the course of the Boiler Code Committee's work during the past four years, many suggestions have been received for revisions of the Power Boiler Section of the Code, as a result of the interpretations issued and also of the formulation of the Locomotive Boiler and the Miniature Boiler Codes. In order that due consideration might be accorded to these recommendations, the Committee began in the early part of 1921 to devote an extra day at each of its monthly meetings to the consideration of the proposed revision. As a result of this many of the recommendations have been accepted and revisions of the paragraphs formulated.

In connection with the revision work, the lack of rules and specifications relative to pipe, pipe material and fittings for use in connection with steam boilers up to the flanges for the connection of the first valves, has been apparent. The Committee has endeavored, at the urgent request of many manufacturers, to supply this lack by rules and specifications which have been prepared in coöperation with the American Society for Testing Materials. These rules and specifications are here published and it is the request that they be fully and freely discussed so that it may be possible for any one to suggest changes before the rules are brought to final form and presented to the Council for approval. Discussions should be mailed to C. W. Obert, Secretary to the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Boiler Code Committee for consideration.

RULES FOR PIPE, PIPE MATERIAL AND FITTINGS USED ON STEAM BOILERS

X-1 Piping and Fittings. The piping and fittings used on boilers up to the flanges for the connection of the first valves from the boiler on steam outlets, feed lines and blow-off lines shall conform to the rules given in *X-1* to *X-6*, and it is desirable that all piping, valves and fittings used on steam and exhaust lines, including the vacuum system and drain lines; all water lines, including boiler-feed suction and discharge lines; and all boiler blow-off lines shall conform to them.

X-2. Steam Pipe. Piping for steam mains carrying saturated or superheated steam may be of welded or seamless pipe made of wrought iron or steel. For sizes above 3 in. in diameter the steel

pipe shall be of open-hearth steel. All pipes shall be straight and free from blisters, cracks, laminations and other injurious defects. Liquor marks and lap-seam lines incidental to the manufacture of pipe will not be considered defects. Each length of pipe is to be inspected separately for defects on the inside and outside, noting particularly the character of the cross-section when cutting off crop ends. Pipe up to 3 in. in diameter may be butt-welded or lap welded while that above 3 in. in diameter shall be lap-welded. Pipe material shall correspond with that required by the specifications of wrought-iron and steel pipe included in Par. *X-9*, et seq.

X-3. Thickness of Steam Pipe. In determining the thickness to be used for pipes at different pressures and for temperatures not exceeding 700 deg. fahr. the following formula is to be used:

$$P = \frac{2\ S(t - 1/16)}{D}$$

where

P = the working pressure in lb. per sq. in. above atmosphere
t = thickness of wall in inches
D = inside diameter of pipe in inches
S = 3500 lb. per sq. in. for seamless steel pipe
= 3200 lb. per sq. in. for lap-welded steel pipe
= 2500 lb. per sq. in. for butt-welded steel pipe
= 2500 lb. per sq. in. for lap-welded iron pipe
= 2000 lb. per sq. in. for butt-welded iron pipe
= 2000 lb. per sq. in. for brass pipe
= 2000 lb. per sq. in. for copper pipe.

X-4. Feed Lines. High-pressure hot-water and cold-water lines may be made of welded or seamless pipe of wrought-iron or steel as called for under *X-2*. Where the water contains corrosive material or air, brass or copper tubing may be used. In determining the thickness of water pipe the following formula will be used:

$$P = \frac{2\ S\ (t - 3/32)}{D}$$

where: P = water pressure in lb. per sq. in.
t = thickness of pipe in inches
D = inside diameter of pipe in inches
S = 2625 lb. per sq. in. for seamless steel pipe
= 2400 lb. per sq. in. for lap-welded steel pipe
= 1875 lb. per sq. in. for butt-welded steel pipe
= 1875 lb. per sq. in. for lap-welded iron pipe
= 1500 lb. per sq. in. for butt-welded iron pipe
= 1500 lb. per sq. in. for brass pipe
= 1500 lb. per sq. in. for copper pipe.

Where brass pipe is desired for finish or for any other reason it may be used. The brass and copper pipes used shall correspond to the specifications given under Pars..... and the brass pipe shall be half-annealed in order to leave it in proper condition for use in feed-water piping.

X-5. Blow-off Piping. Blow-off pipe is to be of extra strong size and to be made of genuine wrought iron or steel as preferred.

X-6. Pipe Bends. Pipes when bent may be made of steel or wrought iron and after bending are to be free from buckles and blisters and practically circular in cross-section. They are to be bent before being threaded or flanged, and where flanged they are to be refaced to dimensions so that they may be bolted or faced without forcing. Where possible, the tangent length of pipe at the end of each bend should be of a length equal to at least twice the nominal diameter of the pipe, although tangents may be used with lengths which are equal to the nominal diameter of the pipe. The advisable radius to which pipe should be bent should be five or six times the nominal diameter of the pipe, although pipe may be bent to a radius equal to four times the diameter of standard pipe and three and one half times the diameter for extra strong pipe up to 12 in. The thickness of the pipe is to be determined by the formula given in *X-3*. The boiler-feed-line bends are to conform with the above, while for blow-off lines the rules are to be applied to extra strong pipe.

SPECIFICATIONS FOR WELDED AND SEAMLESS STEEL PIPE

X-7. These specifications cover "standard" and "extra strong" welded and seamless steel pipe, but not "double extra strong" pipe. Pipe ordered under these specifications are intended for bending, flanging and other special purposes.

I—Manufacture

X-8. (*a*) The steel for welded pipe shall be of soft weldable quality made by the bessemer or open-hearth process. The steel for seamless pipe shall be made by the open-hearth process.

(*b*) Welded pipe 3 in. or under in nominal diameter may be butt-welded, unless otherwise specified. Welded pipe over 3 in. in nominal diameter shall be lap-welded.

II—Chemical Properties and Tests

X-9. Open-hearth steel shall conform to the following requirement as to chemical composition:

Phosphorus.....................not over 0.05 per cent

III—Physical Properties and Tests

X-10. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	Welded: Bessemer	Welded: Open-hearth	Seamless Open-hearth
Tensile strength, lb. per sq. in.	50000	45000	48000
Yield point, " " "	30000	25000	26500
Elongation in 8 in., per cent	18	20	18

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

X-11. (*a*) Welded pipe shall be tested at the mill to the hydrostatic pressures specified in Table I.

TABLE I HYDROSTATIC PRESSURES FOR WELDED STEEL PIPE
(Black and galvanized. Pressures expressed in pounds per square inch.)

Size, (nominal inside diameter), in.	"Standard" Pipe: Weight of pipe per linear foot, threaded and with couplings, lb.	"Standard" Pipe: Butt-weld	"Standard" Pipe: Lap-weld	"Extra Strong" Pipe: Weight of pipe per linear foot, plain ends, lb.	"Extra Strong" Pipe: Butt-weld	"Extra Strong" Pipe: Lap-weld
1/8.....	....	700	....	....	700	....
1/4	....	700	....	....	700	....
3/8.....	....	700	....	....	700	....
1/2.....	....	700	....	....	700	....
3/4.....	....	700	....	....	700	....
1.......	....	700	....	....	700	....
1 1/4.....	....	700	1000	....	1500	2500
1 1/2.....	....	700	1000	....	1500	2500
2.......	....	700	1000	....	1500	2500
2 1/2.....	....	800	1000	....	1500	2000
3.......	....	800	1000	....	1500	2000
3 1/2.....	....	...	1000	....	....	2000
4.......	....	...	1000	....	....	2000
4 1/2.....	....	...	1000	....	....	1800
5.........	....	...	1000	....	....	1800
6.......	....	...	1000	....	....	1800
7.......	....	...	1000	....	....	1500
8.......	25.00	...	800	....	....	....
8.......	28.81	...	1000	43.39	....	1500
9.......	34.19	...	900	48.73	....	1200
10.......	32.00	...	600	....	....	....
10.......	35.00	...	700	....	....	....
10.......	41.13	...	900	54.74	....	1000
11.......	46.25	...	800	60.08	....	1000
12.......	45.00	...	600	....	....	....
12	50.71	...	800	65.42	....	1000

For pipes over 12 in. in inside diameter, the test pressures should be calculated by the formula $P = 2St/D$, in which P = pressure in pounds per square inch; S = fiber stress = 12,000 lb. per sq. in.; t = thickness of wall in inches; D = inside diameter in inches.

(*b*) Seamless pipe shall be tested at the mill to hydrostatic pressures not exceeding that required by the formula:

$$P = \frac{2\ S\ t}{D}$$

in which P = pressure in pounds per square inch; S = allowable fiber stress = 16,000 lb. per sq. in.; t = thickness of wall in inches; and D = inside diameter in inches.

X-12. (*a*) For lap-welded pipe over 2 in. in diameter, a section of pipe 6 in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks.

(*b*) For butt-welded pipe over 2 in. in diameter, a section of pipe 6 in. long shall be flattened between parallel plates until the distance between the plates is 60 per cent of the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks.

X-13. For pipe 2 in. or under in diameter, a sufficient length of pipe shall withstand being bent cold through 90 deg. around a cylindrical mandrel the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld.

X-14. (*a*) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs.

(*b*) Tension test specimens shall be longitudinal.

(*c*) All specimens shall be tested cold.

X-15. One of each of the tests specified in Pars. *X-10, X-12* and *X-13* may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

X-16. If the results of the physical tests of any lot do not conform to the requirements specified in Pars. *X-10, X-12* and *X-13*, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

IV—Workmanship and Finish

X-17. For pipe $1^1/_2$ in. or under in inside diameter, the outside diameter at any point shall not vary more than $^1/_{64}$ in. over nor more than $^1/_{32}$ in. under the standard size. For pipe 2 in. or over in inside diameter, the outside diameter shall not vary more than 1 per cent over or under the standard size.

X-18. Unless otherwise specified, pipe shall conform to the following regular practice:

(*a*) Each end of standard welded pipe shall be threaded.

(*b*) Extra strong welded pipe and standard and extra strong seamless pipe shall be furnished with plain ends.

(*c*) All threads shall be in accordance with the American Standard and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard, when tested with the standard working gage, shall not exceed a maximum of one and one-half turns either way.

(*d*) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings may be made of wrought iron or steel.

X-19. The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed.

V—Inspection and Rejection

X-20. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of charge, all reasonable facilities to satisfy him that the pipe are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

SPECIFICATIONS FOR WELDED AND SEAMLESS WROUGHT-IRON PIPE

X-21. These specifications cover "standard" and "extra strong" welded wrought-iron pipe, but not "double extra strong" pipe.

X-22. All pipes to be used on locomotives and cars shall be of coiling or bending quality.

I—Manufacture

X-23. (*a*) The iron shall be made from muck bars, made from puddled pig iron, free from any admixture of iron scrap or steel.

(*b*) All pipe 3 in. or under in nominal diameter may be butt-welded, unless otherwise specified. All pipe over 3 in. in nominal diameter shall be lap-welded.

X-24. Iron Scrap. This term applies only to foreign or bought scrap and does not include local mill products, free from foreign or bought scrap.

II—Physical Properties and Tests

X-25. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	40,000
Yield point, lb. per sq. in.	24,000
Elongation in 8 in., per cent	12

(*b*) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed $^3/_4$ in. per minute.

X-26. All pipe shall be tested at the mill to the hydrostatic pressures specified in Table I.

X-27. A section of pipe 6 in. in length shall be flattened unti broken by repeated light blows of a hammer or by pressure; the fracture developed shall have a fibrous appearance.

X-28. For pipe 2 in. or under in diameter, a sufficient length of coiling or bending pipe shall withstand being bent cold through 90 deg., around a cylindrical mandrel the diameter of which is 15 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld.

X-29. (*a*) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs.

(*b*) Tension-test specimens shall be longitudinal.

(*c*) All specimens shall be tested cold.

X-30. One of each of the tests specified in Pars. *X-25, X-27* and *X-28* may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

X-31. If the results of the physical tests of any lot do not conform to the requirements specified in Sections *X-25, X-27 and X-28*, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

III—Workmanship and Finish

X-32. (*a*) For pipe $1^1/_2$ in. or under in inside diameter, the outside diameter at any point shall vary not more than $^1/_{64}$ in. over nor more than $^1/_{32}$ in. under the standard size. For pipe 2 in. or over in inside diameter, the outside diameter shall vary not more than 1 per cent over or under the standard size.

X-33. Unless otherwise specified, pipe shall conform to the following regular practices:

(*a*) Each end of standard pipe shall be threaded.

(*b*) Extra strong pipe shall be furnished with plain ends.

(*c*) All threads shall be in accordance with the American Standard and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard, when tested with the standard working gage, shall not exceed a maximum of one and one-half turns either way.

(*d*) Each length of threaded pipe shall be provided with one coupling, having a clean-cut thread of such a pitch diameter as to make a tight joint. Couplings shall be of wrought iron.

X-34. The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed.

IV—Inspection and Rejection

X-35. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of charge, all reasonable facilities to satisfy him that the pipes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

X-36. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

Koninklijk Instituut van Ingenieurs Celebrates 75th Anniversary

The congratulations of The American Society of Mechanical Engineers are extended to the Koninklijk Instituut van Ingenieurs which celebrated its seventy-fifth anniversary on September 8, 1922. A commemorative medal of this anniversary, which was presented the Society, bears on one side the inscription of the Institute and on the other 1847–1922 To the American Society of Mechanical Engineers.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

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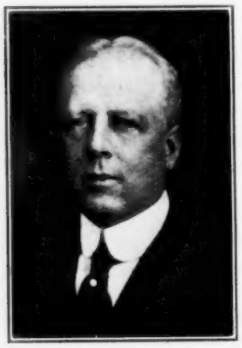
Our Future Lumber Supply—A Challenge to Engineers

The United States Forestry Service is authority for the statement that at the present rate of lumbering, the forests of the United States will disappear in between fifty and sixty years. The full significance of this situation challenges the attention of the engineer, who best knows the power and irrigation needs of the country and who understands the dependence of water power and water supply upon forest maintenance.



Charles H. MacDowell

Furthermore the engineer is directly interested in the maintenance of a supply of timber for construction, mining and maintenance purposes. He wants this timber produced in sections tributary to efficient transportation and near consuming points, that its cost may be kept within reasonable limits. He knows that the timber he is now using comes a longer distance and bears an average transportation charge much higher than it did a few years ago. As he looks ahead, he anticipates still higher costs, greater transportation difficulties and a definite shortage of supply. As his training is more impersonal than that of the business man, as he deals with known facts and actual materials, as he is not an opportunist dealing mostly with the present, he is naturally concerned over the problems of the future and gives thought to their solution before they become acute.

He knows that efficient, low-cost mining of fuel and other materials is favorably influenced by a supply of cheap timber. He appreciates that railway sleepers, piling and bridge timbers must constantly be renewed, that other old construction must be kept usable and that new work will call for more and more timber notwithstanding the increasing use of steel, concrete, brick, tile and stone. He is informed on the wood-pulp needs of the country. He studies the wasteful, improvident methods of the past in tillage clearing, in lumbering and in swamp reclamation—and its continuance in many sections today. He reads almost daily of vast damage to growing timber from forest fires, often kindled by careless campers or hate-everybody vandals, and he reaches the conclusion that a tree has little present-day standing in its community, that the public generally has small conception of the service the tree has rendered and must continue to render, if all is to go well. He knows that we are destroying and not replanting and he appreciates where that policy leads to.

Upon a realization of the responsibility of the engineering profession, the American Engineering Council appointed a Committee on Reforestation which has studied the situation and is working out a policy. The problem is severe and has many ramifications leading into the social, economic, and legislative phases which demand that, to be effective, the Committee must coöperate fully with other bodies who have spent much effort on the subject. All of this requires time to accomplish thoroughly. In the meantime, however, the Forestry Service has the facts and statistics and the engineering profession can immediately assist in their publication and interpretation to the public.

The engineer has a vision of the future of American industry, his profession is that of building and constructing, and he knows that a crop of trees cannot be grown in less than thirty years. If our civilization is to develop, we must have timber and water, and trees must be planted now that our children may live. Trees must be saved, and in forest districts local engineering societies can be of great assistance in developing campaigns for the prevention of forest fires. Activity should not be limited, however, to forest districts. Every local engineering group may, with great benefit to the community and to posterity, discuss the problem as related to the state and nation and stir the public to a realization of the need for a policy that will perpetuate our lumber supply.

Charles H. MacDowell.[1]

The Potential Flying Man Power of America

The following figures may throw some light on one of the problems facing the further development of the aeronautical industry. They refer chiefly to the human material available for service as pilots of commercial passenger-carrying machines of the present types.

The combined experience of the Air Services of the United States and the Allies goes to show that twenty-five years is about the upper limit of age for fliers, although in a number of instances much older men have done excellent service.

As regards the lower age limit, it may be said that while in war service, boys of eighteen have shown splendid courage, it is nevertheless believed that for commercial service none younger than twenty-one ought to be employed. The same war experience has developed the fact that roughly only one out of every one hundred young men possesses sufficient mental development and satisfactory physique to stand the strain of flying. The registration in the first draft showed that there were ten and a half million men in the United States between the ages of twenty-one and thirty-one, or, roughly, one million for each year of age, which would mean four million between the ages of twenty-one and twenty-five. Adding another million to allow for possibilities in the way of exceptionally well-preserved older men, we have five million as our source of flying-man-power material. However, from this number about one million would have to be eliminated to cover unavailable colored population and aliens only temporarily located in the country, leaving a remainder of four million, which, with the ratio of one in a hundred referred to above, gives 40,000 as the apparent maximum number of young men available for service as pilots of commercial passenger-carrying machines.

The experience of the Air Service has shown, however, that college men and men coming from the upper-middle classes of society, due to their better training and better home living conditions, form the majority of those acceptable as pilots. Of course only comparatively few such men would take up thedriving of commercial aeroplanes as a regular occupation, and it would therefore be reasonable to assume that at best not more than one-half of the men available for this service would actually go into it, which reduces the number to 20,000. At an average load of six persons per machine, we therefore have a potential transportation capacity of

[1] Chairman Reforestation Committee of the F.A.E.S. and President of the Western Society of Engineers.

120,000 passengers, which would be materially cut down by the fact that a pilot cannot fly every day.

In fact, with but 20,000 men engaged in the service it would be difficult to keep more than 10,000 machines in the air at any one time, and this, with the average load mentioned, would mean only 60,000 passengers. If we take into consideration the fact that it was only when the automobiles in the country began to be numbered by millions that they became a factor in transportation, we are led to believe that the time when aerial transportation will attain the dignity of an essential industry is still quite distant, unless, of course, the present aeroplane shall be so rebuilt that it will either carry a far larger number of passengers than it does today, or like the automobile, can be driven by any man of ordinary intelligence and average physical qualifications.

The Engineer in Government

[An extract from an interview with Edwin Ludlow, Past-President of the American Institute of Mining and Metallurgical Engineers, which appeared in various forms in the *New York World*, the *New York Tribune* and the *Boston Globe*.—Ed.]

"We have an engineer's civilization and a lawyer's government. Although George Washington, our first president, was an engineer, there have been very few engineers in the Government since, and until Mr. Hoover's selection none has held a cabinet position. This is not by way of complaint. It is a simple statement of fact which, if properly understood, may do much to clear up some of the difficulties which confront America today.

"Engineers do not want a government of engineers. They want a government in which engineers can function on jobs that require engineering, while other services will be performed by those who have the peculiar training which is required for them.

"Engineers do not aspire to the bench, although they could do much to prevent crime and make life move along so smoothly that the courts would not be overworked, as they are at present. I am not one of those who think that government can dispense with lawyers. We need to keep track of precedents. We cannot scrap a whole society as we would rebuild a boilerhouse, for the reason that it takes a generation or two to do the job and a whole people must live in that society while it is being scrapped.

"But government must adopt engineering standards if it is not to become so divorced from the people as to be eventually intolerable. It must adopt them because life has adopted them, because the voter no longer lives merely in his voting precinct, but in his industrial connections, which extend in infinite ramifications throughout the country.

"We don't want a government by any one group, but we do want a government in which the knowledge acquired by every group shall be utilized for the public interest."

"A Healthy State of Change"

REFERRING to the hydraulic turbine in a paper published in this issue of Mechanical Engineering, Mr. H. Birchard Taylor and Lewis F. Moody say that after having reached what was considered for a number of years nearly standardized design, this prime mover "is again in a healthy state of change."

It is not always realized how vigorous and general is this state of flux throughout the world of engineering. In the words of a divine of the 16th century, "Nothing is sacred, not even things sanctified by the usage of centuries."

Nothing that has been in use for centuries or decades is sacred to the modern engineer, who is at all times looking for better ways, with the cheerful expectation that they, in turn, will be discarded for something still better as time goes on.

The Survey of Engineering Progress published in the present issue gives numerous examples of this situation. A British company has developed a new high-resistance alloy of high melting point and ability to withstand the action of acids. The Ford Motor Company is busy completing a process for making iron castings direct from the ore, and in this connection uses a mixer with vacuum walls.

In the glassware industry a device for pressing glassware has been developed which is sensitive enough to act in accordance with the degree that the mold is filled with molten material, thus doing mechanically what the brain of the worker had to do formerly.

In the field of prime movers a Diesel engine has been built in which the cylinder heads acting also as pistons are stationary while the cylinders reciprocate, an arrangement which would have been considered as the height of foolishness ten years ago, but which today operates at a mechanical efficiency of sixty-five per cent.

New materials for making cutting tools are appearing all the time, of which iron is no longer the essential constituent; for example, stellite is made up of cobalt and chromium, and copperite of nickel and zirconium. This young family of non-ferrous cutting alloys has now been joined by the Diamond alloy, composed mainly of chromium, molybdenum and tungsten.

In the power-plant field, Ljungström, the designer of the turbine of the same name, presents an air preheater, the remarkable part of which is that it is so built that there is no transference of heat through metal.

Even the staid and conservative locomotive and marine-propulsion industries have not escaped the universal tendency toward "a healthy state of change." Only five years ago the steam locomotive held undivided sway on the rails. Today a large British railroad is employing gasoline locomotives for switching purposes, while a Canadian railroad is going a step further by equipping its switching locomotives not only with a gasoline engine but with a hydraulic drive. In the marine field where paddle wheels and the Ericsson screw propeller have thus far been the beginning and the end, vane wheels and contrary-turning coaxial screw propellers are being tried out with apparently great promise.

There is undoubtedly a state of change, and the welcome thing about it is that it is generally recognized as a healthy one.

The First World Power Conference

The British Electrical and Allied Manufacturers' Association in coöperation with technical institutions and other trade associations in Great Britain has arranged to hold the First World Power Conference in connection with the British Empire Exhibition in the summer of 1924. The purpose of this conference will be to consider how the industrial and scientific sources of power may be adjusted nationally and internationally. The purpose is to be accomplished by considering the potential resources of each country in hydroelectric power, oil and minerals, by conferences of engineers and authorities on industrial research, by consultations of the consumers of power and the manufacturers of the instruments of production, by discussions on the financial and economic aspects of industry, nationally and internationally, and by conferences on the possibility of establishing a Permanent World Bureau for the collection of data, the preparation of inventories of the world's resources, and the exchange of industrial and scientific information through representatives who will be appointed in the various countries.

The officers and advisory committees are made up of outstanding engineers and industrialists in the British Empire and plans are under way for developing, to a similar extent, coöperation in other countries.

Engineers Elected to Assist Eyesight Conservation Council

Two engineers have been elected to the Board of Councilors of the Eyesight Conservation Council of America. They are Prof. Joseph W. Roe, head of the Department of Industrial Engineering in New York University, and Dr. F. C. Caldwell, professor of electrical engineering in Ohio State University.

Professor Roe is a member of the Executive Board of the American Engineering Council of The Federated American Engineering Societies, and president of the Society of Industrial Engineers. Professor Caldwell is chairman of the Committee on Education of the Illuminating Engineering Society. L. W. Wallace, executive secretary of The Federated American Engineering Societies, is president of the Eyesight Conservation Council which is planning surveys in industrial centers and in city and rural schools to determine the economic and physical damage being caused through failure of parents, teachers and factory managers to correct faults which can be remedied.

Engineering and Industrial Standardization

Approval of Existing Standards by the American Engineering Standards Committee

FOR some time the unification and approval of existing standards will necessarily form an important part of this Committee's work. Its Rules of Procedure (Section R-4) provide that "any standard adopted or in process prior to January 1, 1920, may be approved by the Main Committee, if, in its opinion, the standard has been developed by an organization and procedure substantially in conformity with these Rules, or it has, by actual practice, proven its right to become a standard," without the standard having gone through the machinery of a Sectional Committee. While the most satisfactory way of determining the status which a standard has in industry is to submit it to a regularly organized sectional Committee, there are cases in which such a full procedure would be considered a hardship. Hence this provision.

Before acting upon the approval of a standard submitted under Rule R-4, a notice of its submission to the A.E.S.C. is sent to the technical press, and to the industrial association and technical bodies interested, requesting information as to how the standard is meeting the needs of industry. The standard is then referred to a special committee for investigation.

Special Committees

In order to carry out the spi:it of the Sectional Committee method, these special committees contain representatives (accredited for the purpose or regular members of the A.E.S.C.) of those bodies most concerned with the standard under consideration, including the organization submitting the standard. Each special committee must contain, however, at least three members of the A.E.S.C. Usually only organizations most directly interested have representation. This permits these special committees to be small, and hence better fitted for prompt action than they would be if made as large and broadly representative as is the case of regularly organized Sectional Committees.

If the special committee finds that "the standard has been developed by an organization and procedure substantially in conformity" with the Sectional Committee method, approval by the A.E.S.C. is immediately recommended.

In the case of the great majority of existing standards, however, this is not true, and hence the special committee must determine the status which the standard has reached in the industry concerned, and the attitude taken toward it by the principal organizations concerned. Generally, each member of the special committee is able, either formally or informally, to reflect the attitude of the organization he represents. This information is supplemented by that secured from the correspondence resulting from the formal publicity statements mentioned above, and by data and information made available to the Committee from other sources. Of course, these special committees function in a way similar to that laid down for the Main Committee (A.E.S.C.), omitting all consideration of technical detail and confining their attention to personnel, procedure, and status. The special committee does therefore consider and report on the recommendation for the status of the standard as: American Standard, Tentative American Standard, or Recommended American Practice.

Interpretation and Revision

As part of their work of preparing recommendations to the A.E.S.C. on existing standards submitted for approval, special committees recommend the formal designation of one or more organizations as sponsors to provide for the interpretation and future revision of the standard. While the organization submitting a standard is usually found to be the most suitable one to assume the responsibility of a continuing sponsorship, this is not always the case, so careful consideration is always given to this part of the reports.

On June 15 the A.E.S.C. voted to withdraw thec lause in the Rules of Procedure (Section R-4) under which existing standards may be approved without going through the machinery of a Sectional Committee, such withdrawal to become effective January 1, 1924. Hence all standards submitted after that date will be considered by regularly organized Sectional Committees.

VENTILATING CODE SUBMITTED FOR APPROVAL BY A.E.S.C. UNDER RULE R-4

The code for the ventilation of public and semi-public buildings adopted by the American Society of Heating and Ventilating Engineers in 1915 has now been submitted to the American Engineering Standards Committee for approval as American Standard.

This code was prepared by a committee of the American Society of Heating and Ventilating Engineers in response to requests from state commissions, legislative bodies, public-health agencies and other organizations for suggestions to be used in the preparation of legislation and regulation regarding the heating and ventilation of buildings. An endeavor was made to formulate this code in such a manner as to make it cover the general features most essential to the maintenance of public health. It aims to protect the public with the least possible expenditure for equipment and without unnecessarily limiting the methods of obtaining the desired results. Section 1 of the code relates to general matters pertaining to all classes of buildings; the remaining three sections cover the ventilation of schools and colleges, factories, and theaters.

Among the states that have utilized parts of the ventilating code in their regulations are: Illinois, Indiana, Kansas, Massachusetts, Minnesota, New Jersey, New York, Ohio, Pennsylvania, Utah, Virginia and Wisconsin.

A thoroughly representative special committee, including all the important organizations interested in the subject, has been appointed by the American Engineering Standards Committee to investigate the status of this code and the desirability of approving it. Mr. Sidney J. Williams, Chief Engineer of the National Safety Council, is chairman of this special committee. The American Engineering Standards Committee would, therefore, be very glad to learn from those interested the extent to which they make use of this code, and to receive any other information regarding the way the code is meeting the needs of industry.

A. I. E. E. Holds Pacific Coast Convention

The eleventh annual Pacific Coast Convention of the American Institute of Electrical Engineers was held at Vancouver, B. C., August 8 to 11, 1922. Technical papers presented at the opening session were: Power Development on the Colorado River and Its Relation to Irrigation and Flood Control, by O. C. Merrill, secretary of the Federal Power Commission, and 220-Kv. Transmission of the Southern California Edison Company and Some 220-Kv. Researches, by R. J. C. Wood, engineer for the Southern California Edison Company.

Three papers on the subject on high-tension insulators were presented at the morning session on August 9 and four papers on technical education at the afternoon session. The official convention dinner was held Wednesday evening.

H. B. Dwight, electrical engineer for the Canadian Westinghouse Company, Ltd., of Hamilton, Ont., and C. H. Holladay, engineer for the Southern California Edison Company, Los Angeles, Cal., spoke Thursday morning on the subject of transmission systems. A paper entitled Exciter Instability, by R. E. Doherty, designing engineer for the General Electric Company, Schenectady, N. Y., was also presented at this session. The electric propulsion of battleships was discussed by Commander A. M. Charlton, *U. S. S. Tennessee*, at the afternoon session, and in the evening a pictorial symposium of power plant comparisons was delivered by R. J. C. Wood, of the Southern California Edison Co., and Joseph Mini, Jr., of the Pacific Gas & Electric Co.

Among the papers presented at the final technical session on Friday morning were: Electrical Engineering Features of the Electrical Precipitation Process, by G. H. Horne, engineer for the Western Precipitation Company, and Electrical Precipitation of Solids from Smelter Gases, by R. B. Rathbun, of the Research Department of the American Smelting & Refining Co.

F.A.E.S. Report States Facts on Twelve-Hour Shift

Committee on Work Periods in Continuous Industries Presents Report, Entitled Twelve-Hour Shift in American Industry, Embodying Investigations by Horace B. Drury and Bradley Stoughton

AT THE meeting of the Executive Board of the American Engineering Council in Boston on September 8 and 9, the Report of the Twelve-Hour Shift in American Industry was received and ordered to be published. The complete Report will be on sale probably by the middle of October. Its particular appeal to engineers lies in its being a simple statement of facts.

This Report is the result of definite investigations and surveys inaugurated by the Committee on Work Periods in Continuous Industries of The Federated American Engineering Societies. The personnel of this Committee is: Dr. H. E. Howe, Chairman, J. Parke Channing, Fred J. Miller, L. P. Alford, L. W. Wallace, Dwight T. Farnham, R. B. Wolf, and Morris L. Cooke. The Report is in three sections. Part I, prepared by the committee, is a summary of the field reports contained in Part II and Part III and appears in full below, together with excerpts from Part II. Part II is a report by Horace B. Drury on Two-Shift and Three-Shift Operation in the Continuous Industries. Part III, by Bradley Stoughton, is a Comparison of Two-Shift and Three-Shift Operation in the Iron and Steel Industry.

Mr. Drury's investigations of the twelve-hour shift problem in the steel industry and the progress made in this industry in changing from the two-shift day are well known. He is the author of Scientific Management: A History and Criticism, and of Marine and Dock Labor: Work, Wages, and Industrial Relations during the Period of the War. He was senior examiner in industrial relations for the U. S. Shipping Board and for a number of years was in the Department of Economics and Sociology at Ohio State University.

Bradley Stoughton, formerly secretary of the American Institute of Mining and Metallurgical Engineers, has been connected with various steel companies and was at one time Prof. H. M. Howe's assistant at Columbia University. He has been vice-chairman of the engineering division of the National Research Council, and is the author of the Metallurgy of Iron and Steel, a standard work on the subject. He is the inventor of a convertor for making steel castings and a process for oil melting in cupolas. Since his resignation as secretary of the American Institute of Mining and Metallurgical Engineers he has devoted his time to private consulting work.

I—The Twelve-Hour Shift in Industry

Introduction

IN 1920 members of the engineering profession began an organized study of the twelve-hour shift or "long day" in the operation of continuous process industry. The spirit of the investigation reflected the firm faith of the engineers in facts, and the method adopted was that of fact finding and fact using. Such a study is within the purview of engineering activities, for engineering includes "the art of organizing and directing human activities" in connection with "the forces and materials of nature."

The first engineering meeting devoted to this subject was held in October of the year mentioned at the Engineers' Club of Philadelphia. The topic considered was the technique of changing from the two-shift to the three-shift system in continuous-process industries.[1] The papers and discussions at this meeting gave experiences in changing the basis of operation in the manufacture of paper, heavy and light chemicals, oil and cement, and in mining, in supplying water and in several other industries. There was a common technique throughout all these experiences. The record of this meeting, however, did not show to what extent these successful though isolated cases had influenced the respective industries to which they belonged.

Shortly after this meeting an investigation was conducted to determine the progress made in the steel industry in changing from the two-shift day. This study was made possible by a grant from the Cabot Fund. The work was done by Horace B. Drury who reported at a joint meeting of engineering societies held in New York in December, 1920.[1] In this report were listed upward of 20 small steel plants which had changed from the two-shift to the three-shift system with more or less success. It was recognized and stated that the problem of working a like change in the plants of the U. S. Steel Corporation and the large independents, such as Jones & Laughlin and the Bethlehem Steel Company, was quite different from that encountered in the smaller plants.

Early in 1921 the Taylor Society requested the International Labor Office at Geneva to inquire into the status of two-shift work in countries other than the United States. A report was recently issued from the Washington office in memorandum form.[2] It is to the effect that the shorter day is now completely established in the 15 foreign countries answering the questionnaire. Early in 1921 Mr. Drury completed an inquiry into the twelve-hour shift problem of the larger steel manufacturers in the United States. This report was issued in 1922 by the Cabot Fund Trustees. Also in 1921 the Cabot Fund made a grant to The Federated American Engineering Societies to carry on the two studies forming this report. The committee on Work Periods in Continuous Industry was appointed to direct the investigation. To Mr. Drury the committee assigned the task of ascertaining:

1 The extent of two-shift work in continuous-process industries other than the manufacture of iron and steel;

2 The experience of those manufacturers who had changed from two-shift operation to the three-shift or some other system.

To Bradley Stoughton the committee assigned the task of studying and reporting upon the technical aspects of changing from a two-shift to a three-shift system in the iron and steel industry.

There is no direct relationship between the question of abandoning the twelve-hour shift system and the question of adopting the eight-hour shift system. In a sense it is accidental that most employers in changing from the long day have been forced by the mathematics of the situation to adopt a system of three shifts of eight hours each. Certainly the change itself has involved no judgment as to the relative merits of a working day of eight hours as compared with a working day of any other length shorter than 12 hours.

Relatively only a small part of industrial work, 5 per cent to 10 per cent, is on processes which require continuous operation and the number of workers is relatively few. The desirability of abandoning the two-shift system lies not in its extent but in the fact that the 12-hour shift day is too long when measured by twentieth-century ideas as to the proper conduct of industry. Decisions are influenced today by humanitarian considerations as well as the economic, which demands that length of a day which will in the long run give maximum production.

This declaration the Committee believes is not controversial.

Further, there is practical unanimity of opinion in industry as to the desirability of the change provided the economic loss is not too great. The weight of evidence indicates that the change can usually be made at a small financial sacrifice on the part of the workers and of the management. Under proper conditions no economic loss need be suffered. In certain instances, indeed, both workers and stockholders have profited by the change.

Facts developed by our investigation definitely prove that there is no broadly applicable way of striking a balance between the losses and gains inherent in the change from the two-shift system of operation. If any one fact stands out above the others it is that the change cannot advantageously be made by fiat. Our judgment is that to effect the change suddenly or without adequate preparation is sure to result in lowered production. It is also our opinion that when the change is preplanned and the coöperation of every one is enlisted gains will accrue to every one concerned—to workers, management, owners and the public.

[1] See *Journal* of the Philadelphia Engineers' Club.

[1] For summary see *Iron Age*, vol. 109, no. 20, May 19, 1922.

[2] See *Bulletin* of the Taylor Society, vol. VI, no. 1.

II—Continuous-Process Industries

The Drury report is a general survey of all industries operating continuously twenty-four hours a day, with special consideration to industries other than iron and steel.

There are few continuous industries which do not have twelve-hour plants. Of some forty or fifty continuous industries a number are overwhelmingly on three shifts. The majority are partly on two shifts and partly on three shifts with three-shift operation in the preponderance. There are a half-dozen industries in which two-shift operation is so nearly universal that it is difficult to find an exception. Outside the steel industry the total number of employees on eight-hour shifts is now considerably larger than the total number of employees on twelve-hour shifts. Taking into consideration all continuous industries, between one-half and two-thirds of all workers on continuous operation are on shifts averaging twelve hours.

The leading continuous industries are:

Group I:

Iron and steel	Lime
Non-ferrous metals	Brick
Glass	Pottery
Portland cement	

Group II:

Heavy chemicals	Glue
Fertilizers	Drugs, etc.
Explosives	Electrochemical industries
Dyes	Sugar
Industrial alcohol	Table salt
Wood distillation	Petroleum
Refined corn products	Cottonseed oil
Soap	Other oils

Group III:

Paper	Automobiles
Flour	Textiles
Rubber	Mines
Breakfast foods	

Group IV:

Power	Street railways
Gas	Telegraph and telephone
Water supply	Mails and express
Ice	Policemen, firemen
Shipping	Watchmen
Railroads	

Non-Ferrous Metals. The three-shift system prevails in the non-ferrous metal industries. The change took place during the War, spreading from the West to the East and South.

Glass and Cement. Until recently (1922) the twelve-hour shift was the rule for glass-furnace workers. Other employees about a glass plant are on eight-hour day work. At one window-glass plant, out of 1,300 employees 175 were on a twelve-hour basis. About six years ago the Pittsburgh Plate Glass Co. went to three shifts. Three years ago the majority of other producers went on three shifts.

The cement industry is the second most important industry predominantly on two shifts. In 1920 the largest and third largest companies changed to three shifts.

Lime. About 15 per cent of the men in the plants investigated were on shift work. In most parts of the country the lime industry is uniformly on two shifts.

Brick and Tile, Etc. There are more than 100,000 men in the United States employed in this industry, of whom about 11,000 are on shift work—for the most part on two shifts. In some Philadelphia plants men are on duty 36 hours at a stretch. In Illinois many plants have changed to the three-shift system.

Chemical Industries. Most of the producers of heavy chemicals are on three shifts. Acid-plant employees in fertilizer works are almost universally on twelve-hour shifts. Most continuous-process workers employed in explosive, industrial alcohol and soap plants are generally on this shift. Drug plants are on three shifts. The Niagara Falls electrochemical industries are on three shifts.

Sugar, Salt, Petroleum, Cottonseed Oil, Etc. The Louisiana sugar mills are for the most part on twelve-hour shifts. One sugar refinery in Texas tried three shifts and later reverted to two. The American Sugar Refining Co. changed to three shifts in 1918. Nearly all the beet-sugar plants are on twelve-hour shifts, 210 out of the 225 employees at one Michigan plant being so employed.

In the salt plants the twelve-hour day was formerly almost universal. In Michigan half the men are on shift work—mostly on three shifts.

No examples of two-shift work were found in the petroleum industry. The plants of the Standard Oil group are uniformly on three shifts. Cottonseed crushing presents one of the largest twelve-hour shift problems during the months in which the plants are in operation. Nearly all employees are shift workers in this industry.

Paper, Flour, Rubber, Etc. There are about 88,000 persons in the paper industry, most of whom are on continuous-operation work, although the tendency is toward less shift work. Most of the plants operate on three shifts. Thirty per cent of the workers in Massachusetts were in 1912 on twelve-hour shifts and 70 per cent on eight-hour shifts. In 1921 one of the large associations of paper manufacturers reported 20 per cent of the workers still on two shifts.

Practically all the large flour mills are on three shifts. Most rubber plants have operated under the three-shift system since their establishment.

Automobile plants are for the most part on eight-hour shifts, of which they usually operate two or three shifts per twenty-four hours.

The preparation of cereal foods is usually on three shifts. Some plants use the three-shift operation for women and the two-shift for men. In the textile industry the three-shift plan is used to some extent in the North, but in the plants in the South two shifts are employed, the length of the shifts varying greatly. The hours of work in mines, because of the influence of trade unions, and the nature of the work are fixed at about eight hours per day, with some exceptions in auxiliary occupations, as for engineers, firemen and pumpmen.

Power, Gas, Water Supply, Etc. Work periods in power plants are usually arranged for overlapping shifts of different lengths to provide for variations in the degree of activity. The power departments of factories have been run on the twelve-hour shift down to the last few years. At present there is a tendency to put engineers and firemen on three shifts. The proportion of shift workers in gas works is large. There has been a retention of the system of nine or ten-hour overlapping shifts. In Philadelphia and outlying districts the ten-hour shift is used in conjunction with the eight-hour shift. Water-works plants require less labor for continuous operation than any other public utility. Most plants are now on eight-hour shifts.

Conclusions

1 As to the extent of continuous work in American industry, there are upward of forty continuous industries operating more or less completely upon a shift system. They employ between 500,000 and 1,000,000 wage earners on shift work. Their families constitute from 1,500,000 to 2,000,000 persons, who are dependent upon earnings from shift work.

There are 300,000 wage earners working on twelve-hour shifts. They and their families number more than one million persons.

2 The logical alternative to the two twelve-hour shift system is the three eight-hour shift system, and this is the usual procedure. Nevertheless, other shift systems have been resorted to in a limited way, in changing from the twelve-hour shift. Among these are:

a Operation for a period shorter than twenty-four hours in each calendar day, permitting of a cessation of work from two to four hours, thus establishing two shifts of ten or eleven hours each

b Arranging the work on a nominal twelve-hour shift, so that it can be completed in ten or eleven hours

c Arranging overlapping shifts, thus securing three nine-hour or three ten-hour shifts in twenty-four hours

d Arranging nine- and ten-hour shifts on the five-shift plan.

3 No technical difficulties have been encountered by an overwhelming majority of the plants which have changed from two- to three-shift operation.

There is usually no relationship between the duration of the proc-

ess and the length of the shift, whether the latter is twelve hours long, or a shorter period.

The seeming disadvantage of having three men instead of two responsible for a given product, process, or equipment is overcome by standardizing procedure and establishing control through precision instruments.

4 It is not possible to give inclusive data as to the effect upon the number of shift workers of the change from two- to three-shift operation, because of variations in conditions. In many small plants the number of shift workers has increased in proportion to the increase in number of shifts. In many large plants the number of shift-workers has remained substantially constant when changing from two- to three-shift operation.

5 The following factors should be considered in changing from two- to three-shift operation:

a The readiness, or unreadiness of the men to do more work per hour under the shorter shift

b The responsibility of management as expressed in planning, supervision and control, which must be of a higher quality than usually prevails under two-shift operation

c The fluctuations in individual earnings and labor costs

d General industrial and economic conditions to determine the time for making the change

e The relationship of work periods for shift and for day workers

f The relationship of wage rates for shift and for day workers

g Number of working days in a week

h Rotation of shifts.

6 The effect of the eight-hour as compared with the twelve-hour shift operation on the quantity and quality of production, absenteeism and industrial accidents has been satisfactory where good management and coöperation of labor have been secured. In practically every major continuous industry there are plants which have increased the quantity of production per man as much as 25 per cent. In a few exceptional cases the increase has been much higher. Evidence shows also an improvement in quality of production following the reduction in the length of shifts.

7 A comparison of wage rates under the eight-hour-shift operation with the rates under the ten-hour shift indicates a general tendency to increase the rate per hour under the eight-hour shift, so that the daily earnings will be the same as they were before the change. In some instances a compromise was made whereby the rate per hour was increased sufficiently to make the daily earnings equivalent to a ten-hour day. In other cases a 25 per cent increase in the rate per hour met with the approval of the men.

8 There is a natural divergence of opinion as to the advantages and disadvantages of the three-shift operation, but the weight of the evidence and the most positive statements are in favor of the three-shift operation.

9 The evidence is conclusive that the extra leisure time of the men under the shorter working day is used to good advantage. It is spent in gardening, truck farming and in doing odd jobs which otherwise would have to be paid for or would not be done at all.

10 A few plants have reverted to the two-shift operation after a trial of the three-shift system. This proportion to the number continuing operation on three shifts is so small as to be negligible. The weight of evidence shows that when a plant changes to three-shift operation it is very unlikely to revert to the former system.

III—The Iron and Steel Industry

The report of Mr. Stoughton deals with the change from the twelve-hour shift to the eight-hour shift in the iron and steel industry from the technical viewpoint. It deals with the practicability of making the change, its effect and the most economical method of changing.

In 1919 the United States Steel Corporation employed approximately 70,000 twelve-hour employees. Altogether, there are perhaps 150,000 wage earners in the entire steel industry on twelve-hour shifts.

A wise executive policy takes into full consideration the importance of the intellectual, the psychological and the physical well-being of labor, realizing that an immediate saving secured by over pressure inevitably becomes a loss in the long run. A refusal to coöperate on the part of the workers is an economic loss. Furthermore it is obviously of no permanent benefit to the men if their hours are shortened beyond the point where the industry can survive under competitive conditions.

The factors to consider in determining the economic number of working hours for a worker are:

a His productivity

b His skill, carefulness, endurance, alertness, intelligence, judgment, regularity, morale and goodwill

c His attraction to the work—so that the industry may benefit from the maximum supply of labor of the highest type

d His persistence in the work so that once he is trained and his qualities known to the management he will remain as an asset to the industry.

Situation in the Iron and Steel Industry. The twelve-hour day is strongly established in the iron and steel industry by long custom and by its unusual adaptability to production requirements.

Recent progress, however, has been in the direction of a shorter day as well as in the reduction of the proportion of men on duty seven days a week. This is shown by the following tabulation which gives the percentage of men so employed.

	Seven days per week		Working 12 hours	
	1910	1920	1910	1920
Blast furnaces	75%	29%	69%	63%
Bessemer mills	18%	12%	65%	75%
Open hearth	24%	17%	76%	50%

Recent improvements in equipment and the adoption of electrical appliances have greatly decreased the frequency and the duration of interruptions of the different processes due to breakdowns, especially in the rolling mills. Also mechanical and other labor-saving devices have lessened the severity of peak loads due to the processes themselves, both in respect to physical endurance and heat exposure. For instance:

1 Oxygen is used to open the tap hole, and mud gun to close it.

2 The cast house with its severe manual labor has been replaced by an arrangement which allows the liquid pig iron to run directly into ladles supported on railroad cars. Under this arrangement a former crew of twenty-one men is reduced to five—sometimes to three men.

3 Ore and the materials formerly piled, shoveled, and wheeled by hand are now handled from railroad cars to the furnace hopper entirely without manual labor. Six handle 2,000 tons when previously it required twenty-three to handle 800 tons. This enables the fillers to work continuously.

4 At the Ford plant (which is a blast-furnace only), instead of allowing the fillers to rest occasionally as is usual in the twelve-hour plants, with consequent lowering of the stock-line level in the furnace and of the furnace efficiency, an automatic record is kept of the level of the stock line in the furnace, of the temperature of the top gases and of the time at which the charging skip makes its trips. Continuous adherence to the standards set can be insisted upon and the rest periods and furnace inefficiency eliminated because of the high wages and the eight-hour day. This condition affects the men in front of the furnace as well as the fillers.

These changes in blast-furnace operation have made possible:

a Reduction in number of workmen

b Increase in overall efficiency

c Elimination of floating gang

d Reduced absence, tardiness, labor turnover

e Greater regularity of operation and loss of time

f Fewer accidents and breakdowns

g Less costly repairs

h Decreased cost of production.

It is emphatically asserted by blast-furnace managers working the eight hours that the higher grade of labor attracted by the shorter hours, the greater care and alertness, better work, and more skillful operation are all reflected in a saving in cost of production as enumerated in the last five items above. Cost figures are confidential but furnace operators working under the eight-hour day assured the investigator on more than one occasion that the cost of producing pig iron is less on the eight-hour than on the twelve-hour day.

At the Ford plant, although the men are paid 75 cents and upward per hour and work only eight hours—as compared with 27 to 30 cents per hour at various twelve-hour plants visited; nevertheless

they make pig iron cheaper than it can be bought. This is attributed to the greater efficiency of labor and of operation.

In the case of open-hearth furnaces:

1 The charging machine has greatly reduced the work of the crew on the charging platform
2 Electric appliances for raising furnace doors, mechanical appliances for changing valves, etc., have reduced labor
3 Oxygen is used in tapping and compressed air for repairing the hole. A mechanical appliance has replaced hand shoveling of recarbonizer into the ladle. Repairs are made with the mud gun.

Economical open-hearth operation is dependent upon the care, expertness, and loyalty of the men. The shirking of duty is costly. Carelessness is more likely to occur on a twelve- than on an eight-hour shift.

In the case of rolling mills, eight-hour-shift operation produces a decided increase of efficiency in the case of the lever men, manifested in:

a Increased output
b Less "cobbles" or spoilage
c Less repairs
d Elimination of "spell hands."

Method of Procedure. To successfully change from the twelve- to the eight-hour shift certain definite preparations must be made:

1 The equipment must be in satisfactory condition to respond to increased intensity of operation
2 The coöperation of the workmen must be secured
3 Necessary labor must be available
4 The technical staff must be prepared to furnish full information regarding available labor-saving appliances
5 Existing "bottle necks" must be eliminated and probable ones avoided
6 Peak loads must be studied with special reference to the installation of mechanical appliances
7 The change must not be made during a period of labor unrest
    a After strife
    b When bitterness exists
    c When mutual confidence is lacking
    d When labor is arrogant or elated by the defeat of the management
8 The change must not be made too suddenly
9 Management must be able to influence thoroughly against
    a Tardiness and absence
    b Deliberate shirking
    c Misuse of extra hours of free time.

10 Where possible, make time studies of the work to determine how much more the twelve-hour crew could produce per hour if it worked with greater efficiency. Pay the same hourly rate for eight hours as for twelve and add a bonus which will enable the men by becoming more efficient to maintain their daily income.

The Economic Situation. The United States has the most profitable iron and steel industry in the world, making more money and more output than all the rest of the world put together and exporting its product in successful competition with foreign countries. The majority of managers and executives with whom the matter was discussed believe that the good of the industry can be better served by eliminating the twelve-hour day than by increasing dividends, provided by means of labor-saving devices and in other ways this step carr be taken without serious injury to the industry.

The fact that already many plants operate successfully on the three-shift system indicates that profits need not suffer if the change is made with wisdom. The cost of all labor on either system at the blast furnace is less than $1 per ton of pig. Judge Gary testified before the Lockwood Committee in June, 1922, that the U. S. Steel Corporation could produce at $2 per ton less than its competitors. This shows what low overhead and technical skill can accomplish.

The operating labor in the case of pig iron is from 5.8 to 8 per cent of the total manufacturing cost. Only a part of the labor in the industry is working the twelve-hour day. If that labor was changed to the eight-hour day and paid as much per day as it is now getting for twelve-hour work even without securing any compensating advantages through increased efficiency, morale, etc., the total manufacturing cost of the product would be increased only from 3 to 15 per cent. This is in most cases less than the variations in cost already experienced by competing plants, due to difference in efficiency of equipment, technical skill, purchasing, location, capital resources, overhead expense and advantages due to good management.

As a matter of actual experience, it is known that some plants have changed from the twelve-hour to the eight-hour day and reduced their labor costs. Others have reduced their total manufacturing costs. Others are operating on the eight-hour day with satisfaction to management and stockholders.

Results in such plants may be summarized as follows:

a Although the plants which have adopted the three-shift system are paying wages a little less than is paid in corresponding plants working twelve-hour shifts, the three-shift plants have sufficient labor, both skilled and unskilled.

b The management believes that the shorter hours attract a better class of labor.

c Every executive interviewed stated that the labor turnover is less on the three-shift system than on the two-shift system.

d Sufficient skilled labor can be trained in the plant if the change is made with the coöperation of the men, and if it is made gradually.

e It is unnecessary to pay a full twelve-hour wage to skilled labor to secure a sufficient number to work the eight-hour day.

Advantages of the Eight-hour Day. The change from the twelve to the eight-hour day has secured results sufficient to compensate in whole or in part for the extra cost:

1 Increased efficiency manifested in increased production per man per hour and per machine per day due to:
    a Better physical and mental condition of the men
    b Better class of men attracted
    c Better conduct of operation
    d More uniform operation
    e Better quality of product
    f Less fuel used
    g Less waste
    h Less repairs to equipment
    i Longer life of apparatus.
2 Better morale resulting in:
    a Less absence and tardiness
    b Less shirking
    c Better discipline due to:
        Better spirit of the men
        Greater pressure which foremen can and will exert because they do not have to hold back out of sympathy for tired men.

3 Elimination of the "floating gang" which is maintained to give twelve-hour men a day off a week.

4 Greater prestige with the public—which is invaluable in time of strife.

General Conclusions

There are certain outstanding conclusions in regard to the change from the twelve- to the eight-hour day which occur in both reports:

1 The tendency throughout the world is toward the abolition of the twelve-hour shift.

2 In almost every continuous industry there are plants which are operating on an eight-hour-shift basis in competition with twelve-hour-shift plants.

3 To make the change from the three-shift operation successfully and economically it is necessary that:
    a The majority of the workmen appreciate the value of the extra leisure
    b The workmen be willing to concede something in the way of daily income. The plan which divides the extra labor cost equally between the men and the company has been acceptable in a number of cases.
    c A survey of the field be made for labor-saving equipment and methods of management which will facilitate the work after the change is made
    d The plant management study equipment and methods of operation and make every change in the plant and in the organization possible to facilitate operation under the three-shift system

e All equipment be in condition to respond to increased intensity of operation

f The workmen be instructed in their duties under the new system and the coöperation of the whole organization be secured

g The extra trained labor required be available

h The time for the change be selected with great care. Periods of labor unrest must be avoided, the success of each step assured before another is taken.

5 In a number of plants where the change has been made with success the management reports these results:

a Better physical and mental condition of workmen

b Improvement in class of workmen

c Less shirking, tardiness, absenteeism and labor turnover and industrial accidents

d Improved spirit and coöperation of workmen

e More exact adherence to instructions as to working methods

f More uniform methods with consequent attainments of standards, etc.

g Better quality of product

h Increased output per man per hour

i Less material used

j Wastes eliminated

k Longer life of equipment and less repairs

l Greater prestige with the public.

Excerpts from Mr. Drury's Report

Mr. Drury's conclusions are reproduced in the foregoing pages. His report gives the results of his investigations in forty-four centers of forty-two continuous industries. A reproduction of the findings in these industries is out of the question in these pages but three short excerpts from the facts relating to cement, soap and sugar refining are of interest and are reproduced here.

Soap

In the manufacture of soap the general sentiment in the industry is against continuous operation. However, about twenty-five per cent of the employees of the Proctor & Gamble Company are on continuous work. In the spring of 1921 this company installed a modification of the three-shift system called the five-shift system. This scheme gives shift workers daily turns of nine or ten hours. The number of shift workers is constant throughout the twenty-four hours and each man reports for duty the same hour each day of the week. This is shown in Fig. 1. The conspicuous feature of this plant is the introduction of two interweaving series of shift workers.

The five-shift system as thus outlined has two important characteristics other than its even succession of nine and ten-hour shifts:

First, never more than half of the men are relieved at any one time, obtaining thereby a greater continuity in the work.

Second, a man does not continue today the work which he did yesterday, but takes up what his neighbor on the parallel shift had been doing. This makes it necessary to teach men to serve in two positions. It will be observed that no shift begins or ends work between 12 midnight and 6 a.m.

At the end of the first six months of operation under this system, the company expressed satisfaction with the plan. The production per hour was as much as under the three-shift system. The results were decidedly better than under the two twelve-hour shift system. The five-shift arrangement meant some more work to teach workmen two different jobs.

Refining of Sugar

More than usual importance attaches to the question as to whether a sugar refinery can operate on three shifts without increasing cost. The industry in manufacturing and retailing is an example of a tremendous business done on a moderate and indeed close margin of profit. Competition is intense. It would be impossible for one company to assume a manufacturing cost substantially higher than others. So it is worth while to give special attention to the experience of the American Sugar Refining Company which went to three shifts in the spring of 1918.

There are two elements in the question of cost: (1) The extra compensation due to increased hourly rates and number of men; and (2) productive efficiency.

In the case of the American Sugar Refining Company the first of these two elements was so favorable on three-shift operation as to practically solve the problem of cost.

At the time of the change in the spring of 1918 there was no demand for

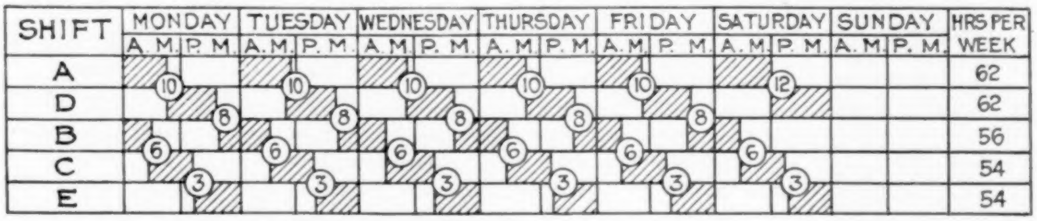


Fig. 1 Five-Shift System, Proctor & Gamble Company

Table I Comparative Labor Efficiency, 86 Portland Cement Plants, 1920 (Data supplied by the Committee on Conservation, Portland Cement Association)

Shift system	Number of plants	Man-hours to produce one barrel: Average all plants in group	Most efficient plant in group	Least efficient plant in group
Two-shift group	51	1.035	0.551	1.940
Three-shift group	22	0.823	0.466	1.540
2–3 shift group	13	0.756	0.470	1.140

Cement

Table I shows comparative labor efficiency in eighty-six plants in the cement industry. In 1920, the year this table was compiled, these eighty-six plants made up between fifty and sixty per cent of the cement-making capacity in the country. The small quantity of man-hours required per barrel of cement when using a combination of two or three-shift systems is especially noteworthy. This combination provides for the use of two-shifts in departments where conditions of temperature and supervision are not so severe.

a reduction in hours, but general conditions were such as to make it likely at any time. It was also expected that an increase in wages would be demanded. In view of the general conditions and the long desire to change to three shifts, the men seized an opportunity to put hours and wages on such a basis as to avoid friction. The management therefore reduced the hours from 12 to 8 and increased the hourly wage rate 50 per cent. The men thereby suffered no appreciable loss in weekly earnings. The company on the other hand did not face any extra wage cost due to the change, for wages in competing plants on a twelve-hour basis were soon increased 50 per cent.

Nevertheless, the change to three shifts also worked out favorably as respects the second aspect of the cost question, the productive efficiency. The company has no exact figures covering the subject but it is the judgment of the men in charge both in the general office and in the largest of the refineries that the efficiency of employees is 15 per cent higher than it was on two-shift operation. The management knows, for instance, that on jobs where the work has remained substantially unchanged, the men are doing more now than their predecessors were doing ten years ago. The figure quoted does not have reference to the output of equipment, but that has

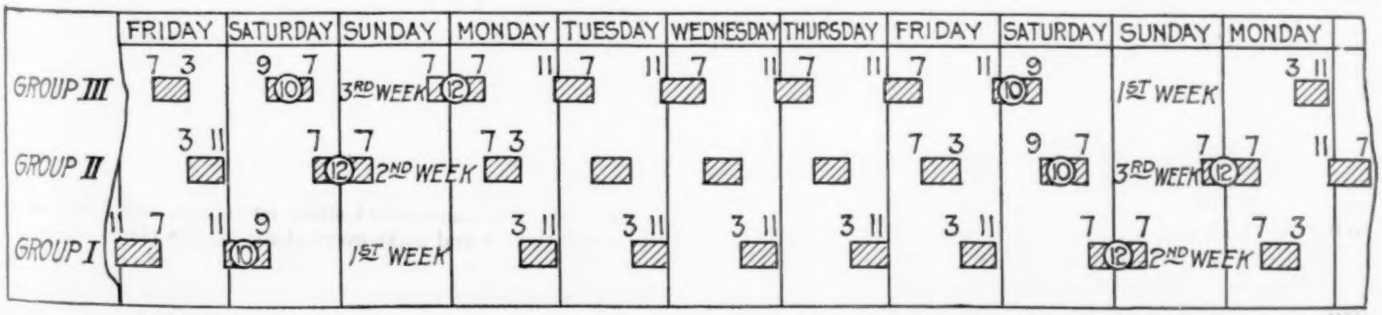


Fig. 2 One Day's Rest in Seven as Worked Out in the Brooklyn Plant of the American Sugar Refining Company

apparently improved. In 1921 the Brooklyn Refinery broke output records for many years past. The management says that absenteeism and labor turnover have decreased.

According to the schedule, the groups work 54, 50 and 52 hours per week, or 52 hours per week average. Overtime is paid for any work done between 7 a.m. Sunday and 7 a.m. Monday, so as to make the average number of hours pay per week amount to 54. But ordinarily the work stops at 6 a.m. rather than 7 a.m. Sunday morning giving an actual weekly average of $53^2/_3$ hours pay.

It will be observed that two Sundays out of three the men get 24 hours off, the third Sunday 54 hours. One week end, a given group works one 10-hour shift; the next week end, it works one 12-hour shift; and the third week end it works a 10-hour shift before and a 12-hour shift after the period off. Through the week all shifts are 8 hours. The minimum rest period between shifts is 16 hours.

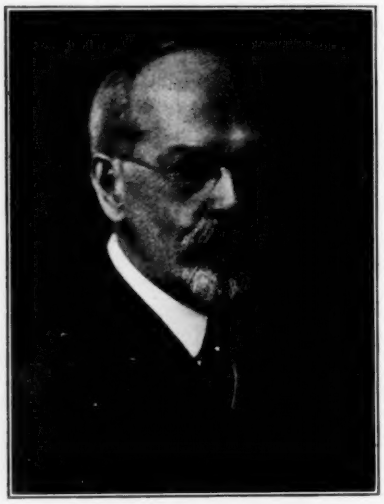
The plant itself operates all but 12 hours, or in practice 13 hours, out of the week.

Fig. 2 illustrates an interesting feature of the three-shift system as worked out at the Brooklyn Refinery. It is a plan for providing one day's rest in seven (as required by the New York State Law) without the introduction of relief men. The day-workers of the American Sugar Refining Company are on a 50-hour week, with a few on 60 hours. On Sunday about 200 men (in the one refinery) work on repair work which can not be done during the week. These men are given a week-day off.

Coleman Sellers, Jr., Former A.S.M.E. Manager, Dies

Coleman Sellers, Jr., was born in Cincinnati, Ohio, September 5, 1852 and died after an acute illness of several months in Bryn Mawr, Pa., on August 15, 1922. Mr. Sellers' health became impaired as a result of his heavy duties during the war as head of the draft board in his district.

After an early education received in the private schools of Philadelphia, Mr. Sellers entered the University of Pennsylvania, where he was a first-honor man throughout his course. He was graduated in 1873 with the degree of Bachelor of Science, and three years later received his Master's degree for shop tests and a thesis relating to steam-boiler injectors. He entered the employ of William Sellers & Co. in November, 1873, and from 1886 to 1902 was assistant manager. In 1902 he was appointed engineer, and on the death of William Sellers was made president of the company. He continued in these capacities until the time of his death.



Coleman Sellers, Jr.

Mr. Sellers was of the sixth consecutive generation of a family engaged in the mechanical arts. His father, Coleman Sellers, a Past-President of The American Society of Mechanical Engineers, had a long career as an inventor. The sound judgment, ingenuity and experience of Coleman Sellers, Jr., contributed in full measure in maintaining the high reputation of his company as a designer of machine tools and appliances in its special field.

From 1890 to 1893 Mr. Sellers served The American Society of Mechanical Engineers on its Board of Managers; he was among the earliest to join the Society, having become a member in 1882. He was also a member of the American Philosophical Society, the American Society of Naval Architects and Marine Engineers, the American Academy of The Fine Arts, the University Club of Philadelphia, the City Club, Contemporary Club, Pennsylvania Society of Sons of the Revolution, and the New England Society of Pennsylvania. He was one of the founders of the Philadelphia Engineers' Club, had served on the Board of Managers and later as vice-president of The Franklin Institute, was a former president of the Chamber of Commerce of Philadelphia, and from 1908 until his death was one of the three State Commissioners of Navigation for the Delaware River.

Book Notes

Les Applications Élémentaires des Fonctions Hyperboliques a La Science de L'Ingénieur Electricien. By A. E. Kennelly. Gauthier-Villars et Cie, Paris, 1922. Paper, 6×9 in., 153 pp., diagrams.

Dr. Kennelly spent the academic year 1921–22 as an exchange professor in France, where he delivered a course of lectures in universities and engineering schools upon the applications of hyperbolic functions to electrical engineering problems. This monograph, based upon these lectures, places before the French student, in abridged form, the material already published in English by the author.

Chain Stores. By Walter S. Hayward and Percival White. First edition. McGraw-Hill Book Co., New York, 1922. Cloth, 6×8 in., 411 pp., illus., $3.50.

This book sets forth the principles of the operation, organization, management and control of chain stores, and is intended for the executive at headquarters, the branch manager and his assistants. The authors hope it will also prove stimulating to independent retailers and others interested in methods of distribution.

Crain's Market Data Book and Directory of Class, Trade and Technical Publications. Second edition, 1922. G. D. Crain, Jr., Chicago. Cloth, 6×9 in., 456 pp., $5.

This is a reference book for advertisers. An account of trade, industry and profession is given which presents the statistical and marketing data necessary to give the advertiser or merchant a picture of the field as a whole. Each account is supplemented by a full list of American trade journals devoted to that industry, with their addresses, circulation, advertising rates, etc. A list of important foreign trade journals is included.

Elektrische Behandlung Von Gasen. Herausgegeben von Henri Silbermann. Dr. Max Janecke, Leipzig, 1922. Paper, 6×8 in., 348 pp., illus., diagrams, $3.20.

This work is a summary of information upon the effect of electric discharges upon gases, especially the atmosphere, as disclosed by an examination of the German patent records. The subjects discussed are the activation of oxygen (preparation of ozone), the separation of solid or liquid particles from gases (purification by dust and mist removal) and the double decomposition of reaction masses containing at least two elements (synthesis of nitric oxid, ammonia, cyanogen, etc.). The book is a convenient record of the present state of these arts.

Elements of Radio Telephony. By William C. Ballard. First edition. McGraw-Hill Book Co., Inc., New York, 1922. Fabrikoid, 5×7 in., 132 pp., illus., plates, diagrams, $1.50.

This book gives a simple discussion of what happens when messages are sent and received by radio, of the apparatus required to produce these effects, and of its method of operation. It also gives practical unbiased information for the experimenter who wishes to learn what apparatus is necessary to produce certain results. Being intended for non-technical readers, the use of mathematics is avoided almost entirely.

The Gantt Chart. By Wallace Clark. Ronald Press Co., New York, 1922. Cloth, 6×9 in., $2.50.

This book explains the principle of this chart, the method of making and reading it, and shows its application to machine, man, planning, load and progress records. One chapter describes their use by the Shipping Board during the war. It will enable those interested to apply this method of charting their records to their own activities.

High-Voltage Power Transformers. By William T. Taylor. Sir Isaac Pitman & Sons, Ltd., London and New York, 1922. (Pitman's technical primer series.) Cloth, 4×6 in., 117 pp., illus., diagrams, $0.85.

A general practical survey of the characteristics, construction, installation, operation and troubles of modern high-voltage power

transformers. Intended for station operators and general electric engineers and so does not treat problems of fundamental design, details of construction and similar topics which chiefly concern manufacturers.

Hydraulics with Working Tables. By E. S. Bellasia. Third edition. E. P. Dutton & Co., New York, 1922. Cloth, 6×9 in., 348 pp., tables, illus., $8.

In this edition the book has been brought thoroughly up to date and subjected to careful and drastic revision. The chief object is, as before, to deal thoroughly with the facts, laws and principles of hydraulics, and to keep always in view their practical aspects. Fresh discussions on all the most important coefficients are now given and specific recommendations are made. A new set of coefficients for pipes is given.

Fresh matter has been added on weirs and weir-like conditions, on discharge measurement by means of pipe diaphragms, on standing waves and on the laws governing silting and scour. The book is intended to meet all the requirements both of the student and of the engineer.

Hydro Electric Installations of India. By Shiv Narayan. The Author, Poona, India, 1922. Cloth, 6×10 in., 302 pp., illus., 9 rupees.

This book presents in popular form the principal facts concerning the hydroelectric plants and projects of India. It also explains the hydraulic and electrical principles involved, the general design and installation of plants and the economic factors to be considered. The work is intended to direct attention to the water-power resources of the country and to serve as a guide to engineers and capitalists interested in the utilization of them.

Industrial Physics; Mechanics. By L. Raymond Smith. First edition. McGraw-Hill Book Co., Inc., New York, 1922. Cloth, 5×8 in., 226 pp., illus., diagrams, $1.75.

The present trend in education has created a demand for textbooks in which the material presented is closely connected with the every-day life of the student. This volume is an attempt to meet this demand by providing an elementary, practical textbook on mechanics, suitable for use in high schools and vocational schools.

Marine Power Plant. By Lawrence B. Chapman. First edition. McGraw-Hill Book Co., New York, 1922. Cloth, 6×9 in., 320 pp., illus., diagrams, $4.

The purpose of this book is to bring before the student the thermodynamics of the marine power plant, the types of machinery used for ship propulsion, and to give him a comprehensive idea of the layout and purposes of the auxiliary machinery. It is intended as a first book in marine engineering for students of naval architecture, marine engineering and ship operation, but should prove useful also to sea-going engineers and shipowners.

Mechanical Testing. By R. G. Batson and J. H. Hyde. Vol. 1. E. P. Dutton & Co., New York, 1922. (Directly-useful technical series.) Cloth, 6×9 in., 413 pp., plates, illus., diagrams, $9.

The object of this book is to place before the engineer, the manufacturer and the student the conditions governing modern testing, the particulars of standard testing-plant equipment and its limitations and the information necessary to appraise the results obtained at their true values. Volume one is confined to materials of construction, metals, timber, stone, brick, concrete, limes, cements and road materials.

Modern Practice in Heat Engines. By Telford Petrie. Longmans, Green and Co., New York, 1922. Cloth, 6×9 in., 264 pp., illus., plates, diagrams, $5.

A concise treatment of the subject of power from heat engines which attempts to show how far theory may be applied to the design of modern types. The book is divided into three sections, steam, prime movers, and internal-combustion engines. Each section contains chapters descriptive of late types and on the principles of design. The results of a number of reliable modern tests are given.

Modern Pumping and Hydraulic Machinery. By Edward Butler. Second edition, revised. Charles Griffin and Co., Ltd., London, 1922. Cloth, 6×9 in., 475 pp., illus., diagrams, $9.

The author has attempted to present in a clear, concise form information specially useful to engineers, designers and others engaged in the construction or application of pumping and hydraulic machinery to various purposes. The whole range of pumping appliances, as well as the machinery used in hydraulic transmission and power generation, is treated systematically and exhaustively.

Practical Wireless Telegraphy. By Elmer E. Bucher. Revised edition. Wireless Press, New York and London. 1921. Cloth, 6×9 in., 336 pp., illus., diagrams, $2.25.

The author endeavors to give non-technical students and practical telegraphers an understanding of the working of modern commercial apparatus. Stress is laid upon the construction of apparatus and the methods of manipulating it, without attempting a complete account of the scientific principles underlying it.

Principles of Leather Manufacture. By H. R. Procter. Second edition. E. & F. N. Spon, Ltd., London, 1922. Cloth, 6×10 in., 688 pp., illus., 32 s.

This treatise deals with the general scientific principles of the industry, without describing in detail its practical methods, although many practical points are discussed. The second edition, issued after an interval of eighteen years, has been thoroughly revised, so that the new points of view occasioned by the advances in physical and colloidal chemistry are covered. The volume is intended for chemists and practical tanners.

Principles of Interchangeable Manufacturing. By Earle Buckingham. First edition. Industrial Press, New York; Lond., Machinery Publishing Co., Ltd., London, 1921. Cloth, 6×9 in., 254 pp., illus., diagrams, $3.

In this treatise the author first takes up the general principles involved in interchangeable manufacturing, and then devotes a chapter to the definition of the terms used. The influence of interchangeable processes on machine design and the purpose of models are then dealt with, and followed by a detailed discussion of the dimensioning of drawings for use in interchangeable manufacturing. This is followed by an account of the principal elements that govern economical production, the equipment required, the gage equipment and the principles of inspection and testing. Special chapters treat manufacturing for selective assembly, small-quantity methods and the service factor in interchangeable manufacturing.

Steam Turbines. By William J. Goudie. Second edition. Longmans, Green and Co., London and New York, 1922. Cloth, 6×9 in., 804 pp., plates diagram., illus. $10.

This book has been written primarily to suit the requirements of engineering students, but the author hopes that the methods of calculation outlined in it will be useful also to engineers engaged in the design or operation of steam turbines. The first portion of the text is devoted to detailed descriptions of commercial representatives of the various types now on the market. The second portion treats what may be termed the "technical" part of the subject; nozzles, blading, rotors, gearing, steam consumption, proportions, governing, etc. This edition has been completely rewritten and enlarged.

Uber die Festigkeitsberechnung von Schiebetoren und Ahnlichen Bauwerken. By Adolf Eggenschwyler. H. A. Ludwig Degener, Leipzig, 1921. Paper, 6×9 in., 148 pp.

This monograph discusses the problems in statics involved in the design of sliding sluice gates, floating docks, movable weirs and similar hydraulic structures composed of steel plates and frames. The statical problems that they present are, according to the author, midway between those of bridge building and shipbuilding; and have until now been much neglected. In consequence, the calculations of designers have been based on false assumptions, which have frequently led to an extravagant use of material and to lack of the necessary strength.

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada.)

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ABRASIVE WHEELS

Nomenclature. Grinding Wheel Nomenclature, H. A. Plusch. Machy. (N. Y.), vol. 28, no. 12, Aug. 1922, pp. 979–980, 1 fig. Brief description of various types of wheels.

ABRASIVES

See EMERY PAPER.

ACCOUNTING

Industrial. Present-Day Problems in Industrial Accounting, Stanley G. H. Fitch. Jl. of Accountancy, vol. 34, no. 1, July 1922, pp. 1–10. Balance-sheet and its connection with profit-and-loss statement; gives various other features of industrial accounting.

AERONAUTICAL INSTRUMENTS

Air-Speed Indicators. Air-Speed Indicators, Franklin L. Hunt. Nat. Advisory Committee for Aeronautics, Aeronautic Instruments Section III, Report no. 127. Description of typical instruments; altitude correction charts; wind-tunnel, static and flight tests; ground-speed measurements.

AIR COMPRESSORS

Centrifugal. Centrifugal Compressors (Les compresseurs centrifuges), Robert Huguenin. Technique Moderne, vol. 14, no. 6, June 1922, pp. 241–250, 10 figs. Characteristics of centrifugal compressors for mines. Tests with compressors at Orange-Nassau mines.

High-Pressure. Calculation of High-Pressure Compressors (Berechnung von Hochdruck-Kompressoren), P. Ostertag. Zeit. des Vereines deutscher Ingenieure, vol. 66, no. 25, June 24, 1922, pp. 649–650, 3 figs. Gives entropy diagram of a multiple-stage piston compressor for a given final pressure for finding pressure, temperature and volume conditions; calculates cylinder dimensions.

Intercooling. Compressor Intercooler Complication, Frank Richards. Power Plant Eng., vol. 26, no. 13, July 1, 1922, pp. 669–670, 2 figs. Moisture in air at different stages of compression.

Transformers. Air Transformer Shows Remarkable Efficiency, D. M. McLean. Power House, vol. 15, no. 14, July 20, 1922, pp. 25–26, 5 figs. Description of device for blowing forge fires and similar purposes.

[See also TURBO-COMPRESSORS.]

AIR CONDITIONING

Air Purifier. The "Vigoratair" System of Air Purification. Eng. Production, vol. 5, no. 95, July 27, 1922, p. 82, 1 fig. Description of details of "portable" air purifier for factory ventilation. See also Machy. (Lond.), vol. 20, no. 510, July 6, 1922, pp. 437–438, 2 figs.

Cooling Buildings. Cooling of Theatres and Public Buildings, Fred Wittenmeyer. Ice & Refrigeration, vol. 63, no. 1, July 1922, pp. 13–14. Capacities for and methods of cooling theaters; test on air-cooling apparatus at Blackstone Hotel; costs.

AIRCRAFT

Structural Strength. Structural Strength of Aircraft. Flight, vol. 14, no. 27, July 6, 1922, pp. 385–386. English certificates of airworthiness to be granted only to design meeting specifications in tables shown for general class and for commercial class.

Testing to Destruction. Testing Aircraft to Destruction, Wm. D. Douglas. Aeronautical Jl., vol. 26, no. 138, June 1922, pp. 195–222 and (discussion) 222–230, 36 figs. Examples of certain types of defects which are revealed by strength tests. Necessity for supplementing calculations. Description of present methods.

AIRPLANE ENGINES

Air-Cooled Radial. The Siddeley Air-Cooled Radial Engines. Aeroplane, vol. 23, no. 3, July 19, 1922, pp. 43–44 and 46, 8 figs. 7- and 14-cylinder engines developing respectively 160 and 320 hp.; gives data of tests.

The Armstrong-Siddeley "Jaguar" Radial Aero Engine. Flight, vol. 14, no. 29, July 20, 1922, pp. 407–410, 10 figs. 14 cylinders disposed in two rows; outfit rated 350 hp.; cylinders have aluminum heads and steel barrels.

Wright. New Wright Engines for Naval Aviation. Aviation, vol. 13, no. 5, July 31, 1922, pp. 124–125, 2 figs. Brief description and data of tests of Wright model E2, 180-hp. engine, and Wright model T2 525-hp. heavy-duty engine.

Wright-Navy Twelve Reflects Progress in Aircraft Engine Design, Herbert Chase. Automotive Industries, vol. 47, no. 2, July 13, 1922, pp. 57–61, 5 figs. Dependability over long periods of operation is combined with low fuel consumption and unusual degree of accessiblity. Engine develop 525 hp. but has same overall length as Liberty-twelve. Open end sleeve used and babbitt bearings eliminated.

AIRPLANES

De Havilland. The D. H. 37. Aeroplane, vol. 23, no. 4, July 26, 1922, pp. 65–67, 12 figs. Three-seater tractor biplane; Rolls-Royce "Falcon" engine.

Bleriot Spad 45. The Bleriot Spad 45 Four-Engined Airliner, John Jay Ide. Aviation, vol. 13, no. 1, July 3, 1922, p. 13, 1 fig. French airplane fitted with four 275-hp. Hispano-Suiza engines accomodates 17 passengers and crew of 3; high speed, 124 m.p.h.

Commercial. The Bellanca CF 5-Seater Cabin Airplane. Aviation, vol. 13, no. 7, Aug. 14, 1922, pp. 183–185, 2 figs. Commercial airplane designed to carry 5 people with fuel for 600-mile flight.

The Design of a Commercial Aeroplane, G. De Havilland. Aeronautical Jl., vol. 26, no. 139, July 1922, pp. 204–211 and (discussion) 211–218. Consideration of this type of engine; construction; stability; passenger accomodations; gasoline systems; controls.

Handasyde Monoplane. The Handasyde Monoplane, Type H. 2. Flight, vol. 14, no. 29, July 20, 1922, pp. 412–416, 16 figs. Describes new cantilever-type machine with novel wing construction.

Landing. Landing of Airplanes (L'atterrissage des Avions), Philippe. Aerophile, vol. 30, no. 7–8, Apr. 1–15, 1922, pp. 101–103, 2 figs. Discusses landing operations and makes calculations of forces in question.

Sport. The Entler All-Metal Sporting Cantilever Biplane. Flight, vol. 14, no. 26, June 29, 1922, p. 375, 2 figs. Product of Entler Works, Wilhelmshaven, Germany. Characteristics: Span (top) 23 ft., (bottom) 19 ft. 6 in.; chord (top) 4 ft., (bottom) 3 ft. 3 in.; length 16 ft. 9 in.; height 7 ft. 9 in.; weight empty, 375 lb.; area main planes, 150.6 sq. ft.; designed speed 80 m.p.h.

The Heath Sport-'Plane. Flight, vol. 14, no. 27, July 6, 1922, p. 381, 3 figs. Single-seater tractor biplane fitted with 20-hp. 2-cylinder Thor air-cooled motorcycle engine.

The Udet Sporting Single-Seater. Flight, vol. 14, no. 28, July 13, 1922, pp. 393–394, 4 figs. Single seater German monoplane of cantilever type equipped with 30–40-hp. Haacke engine.

Strength Calculator for Details. A Strength Calculator for Aeroplane Details. Flight, vol. 14, no. 23, June 8, 1922, p. 330, 2 figs. Description of slide rule for quickly determining sizes of wiring lugs, bracing attachments, bolts, pins, etc.

AIRSHIPS

Stability. The Stability of Airships: Trials with the R33. Indian Eng., vol. 71, no. 23, June 10, 1922, pp. 326–328, 2 figs. Head-on flight; curvilinear flight and results from model attached to a whirling arm and rotated in water.

[See also PARACHUTES.]

ALLOY STEELS

Decomposition of Martensite in. The Decomposition of Martensite Into Troostite in Alloy Steels, Howard Scott. Forging & Heat Treating, vol. 8, no. 7, July 1922, pp. 296–299, 3 figs. Only manganese, silicon and chromium show marked effect; first increased intensity of transformation, last two raised its temperature in certain percentages.

Tests. Heat Tests with Special Steels (Warmversuche mit Sonderstählen), H. Edert. Stahl u. Eisen, vol. 42, no. 25, June 22, 1922, pp. 961–968, 18 figs. Results of tests made with refined, low-percentage chrome-nickel, chrome-vanadium and non-rustable steels. Investigation includes chemical composition, tensile tests, measurements up to maximum temperature of 800 deg. cent., bending tests up to 600 deg., Brinell tests up to 300 deg. and notched-bar tests up to 700 deg.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Diamond. Diamond Alloy—A New Cutting Metal. Machy. (N. Y.), vol. 28, no. 12, Aug. 1922, pp. 958–959, 2 figs. Alloy composed mainly of chromium, molybdenum and tungsten used for making cutting tools.

High-Resistance. Lécfurite—High Resistance Alloy. Machy. (Lond.), vol. 20, no. 511, July 13, 1922, pp. 452–455, 5 figs. Description of new alloy metal fusing at 1,550 deg. cent. and intended for use as resistance wire.

Magnesium. See MAGNESIUM ALLOYS.

[See also BEARING METALS; MONEL METAL.]

ALUMINUM

Casting. Aluminum Casting and Metal Spraying (Vom Aluminium- und Spritzguss). Zeit. für die gesamte Giessereipraxis, vol. 43, no. 28, July 22, 1922, pp. 393–395. Operations in production of aluminum castings and metal for metal spraying.

ALUMINUM ALLOYS

Properties. Improving Aluminum Alloys (Studien an vergütbaren Aluminiumlegierungen), W. Fraenkel and E. Scheuer. Zeit. für Metallkunde, vol. 14, nos. 2 and 3, Feb. and Mar. 1922, pp. 49–58 and 111–118, 15 figs. Processes of improving aluminum alloys with magnesium content; measuring their conductivity, elasticity, e.m.f., velocity of dissolution; determination of density; experiments with alloys containing Mg; change of tensile strength on prolonged heating; effect of tempering; corrosion.

AMMONIA

Synthetic. New Processes and Proposals for the Production of Synthetic Ammonia (Neue Verfahren

Note.—The abbreviations used in indexing are as follows:
Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer[s] (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

und Vorschläge zur synthetischen Gewinnung des Ammoniaks), A. Sander. Zeit. für komprimierte u. flüssige Gase, vol. 22, nos. 1, 3 and 4, 1922, pp. 1–3, 29–32 and 41–43, 2 figs. No. 1: Discusses Haber and Claude processes, and the Hyper-compressor, with which pressures of 1,000 atmos. are reached. No. 2: Discusses Claude process as stated in German patent 341,230, and describes apparatus. No. 3: Production of synthetic ammonia in England, America and other countries.

The Synthesis of Ammonia by Means of High Pressures (La Synthèse de l'Ammoniaque par les Hyperpressions), Georges Claude. Société Industrielle de l'Est, Bul. No. 165, Apr.-June 1922, pp. 46–63, 13 figs. partly on supp. plates. Discusses Haber process; simple way of producing high pressures; work of Linde.

AUTOMOBILE ENGINES

Carburetors. See CARBURETORS.

Chain Front-End Drive. Marked Increase in Use of Chains for Front End Drives, J. Edward Schipper. Automotive Industries, vol. 47, no. 1, July 6, 1922, pp. 8–10, 8 figs. New and original drive layouts permit easy adjustment and cause extensive use of this system.

Crankcase-Oil Dilution. The Crankcase Oil Dilution Problem and Its Solution, Wm. F. Parish. Soc. Automotive Engrs. Jl., vol. 11, no. 1, July 1922, pp. 35–47, 14 figs. Incompletely vaporized fuel leaks into crankcase and dilutes oil thereby decreasing its viscosity; carbon-forming properties of oils and effect of heavy oil on engine efficiency; crankcase oil regeneration.

Crankshafts. See CRANKSHAFTS.

Cylinders. See CYLINDERS.

Manufacture. Manufacturing Practice on Light Motor-Car Power Units. Machy. (Lond.), vol. 20, no. 512, July 20, 1922, pp. 473–477. Methods of Hotchkiss et Cie, Coventry; deals with heat treatment, case-hardening and refining of steels used.

Oil Regeneration. New Plan Regenerates Motor Oil Continuously as Automobile Runs, William F. Parish. Nat. Petroleum News, Vol. 14, no. 27, July 5, 1922, pp. 49–50, 3 figs. Gross crankcase refiner for automatically removing fuel and water dilutions and filtering out foreign substances. From paper read before Soc. Automotive Engrs.

Piston Rings. See PISTON RINGS.

Radiators. Seam Lock is Feature of New Radiator Construction, B. M. Ikert. Automotive Industries, vol. 47, no. 2, July 13, 1922, pp. 66–67, 5 figs. Sections held together by lock; solder acts merely as seal; brass or copper used in making up core is not stretched during construction. Novel machinery utilized in manufacture. Core specially adapted to motor-truck use. Not injured by freezing.

Sleeve-Valve. 10-Hp. Sleeve-Valve Motor-Car Engine. Engineering, vol. 113, no. 2942, May 19, 1922, p. 618, 3 figs. Two-cylinder, horizontally-opposed type made by Vulcan Motor and Eng. Co. which develops 18 b.hp. at 2000 r.p.m.

Straight-Eight Type. The Lessons of Indianapolis, Autocar, vol. 48, no. 1392, June 24, 1922, pp. 1082–1084, 3 figs. Straight-eight engine proves capable of very high sustained speeds. Remarkably high compression ratios adopted.

AUTOMOBILE FUELS

Alcohol-Benzol Tests. Testing Alcohol-Benzol Fuel W. F. Bradley. Motor Transport, vol. 35, no. 905, July 3, 1922, pp. 29–30, 3 figs. Results obtained by Paris Omnibus Co. with over a thousand buses running on 50 per cent mixture.

Detonation. Measuring the Tendency of Various Fuels to Knock, Thos. Midgley, Jr., and T. A. Boyd. Automotive Industries, vol. 47, no. 1, July 6, 1922, pp. 23–27, 5 figs. Relative effectiveness of alcohol, benzol and other substances in preventing detonation are determined by more precise methods than used in earlier tests. Results indicate some conclusions reached by Ricardo are in error. Xylidine effective in small amount.

Fractional Distillation. Fractional Distillations of Fuel and How to Make Them, P. S. Tice. Automotive Industries, vol. 47, no. 3, July 20, 1922, pp. 120–126, 5 figs. Shortcomings of present standard apparatus and development of new type which fulfills desirable characteristics.

Preparation. The Hot-Spot Method of Heavy-Fuel Preparation, F. C. Mock and M. E. Chandler. Soc. Automotive Engrs. Jl., vol. 11, no. 1, July 1922, pp. 27–32 and 48, 7 figs. Investigation of means for preparing kerosene and mixtures of heavier oils with alcohol and benzol for fuel in manifold.

Tetralite Benzol. Recent Development in Automobile Fuel (Die neuere Entwicklung der Motorkraftstoffe), Wa. Ostwald. Zeit. für angewandte Chemie, vol. 35, no. 46, June 9, 1922, pp. 278–280. Development of explosion and Diesel engines; combustion and mixing of fuels; detailed description and analysis of Reichskraftstoff or tetralite benzol, a mixture of 50 per cent benzol, 25 per cent tetralin and 25 per cent spirits.

AUTOMOBILES

Bodies. European Efforts to Reduce Car Weights Bring Radical Body Construction, W. F. Bradley. Automotive Industries, vol. 47, no. 1, July 6, 1922, pp. 11–12. Extreme reduction of weight and noise features Weymann system of body building. Lends itself to production at low cost. Lancia builds a four-passenger, 122-in. wheelbase car weighing 1650 lb. complete. Chassis frame members used as body frame members.

Lumber Situation Demands Utilization of New Woods for Bodies, Geo. J. Mercer. Automotive Industries, vol. 47, no. 1, July 6, 1922, pp. 13–15, 1 fig. Increase in number of closed bodies forces use for less expensive woods. Quality not diminished. Scientific study of substitute woods necessary. Cables to supplement strength of wood possible.

Bow "V." The "Bow V" Car. Auto, vol. 27, no. 28, July 13, 1922, pp. 575–577, 7 figs. Light vehicle with air-cooled engine, 4-speed gear, clutch and starter of motorcycle design, and automobile transmission mechanism.

Brake and Clutch Practice. European and American Automotive Brake and Clutch Practice, H. G. Farwell. Soc. Automotive Engrs. Jl., vol. 11, no. 1, July 1922, pp. 67–80, 27 figs. Analysis of types used on 165 cars exhibited at London Automobile Show 1920, and discussion of best-known types in United States and Europe.

Creeper Track Car. Good Going over Bad Ground. Motor Transport, vol. 35, no. 906, July 10, 1922, p. 62, 3 figs. Remarkable performance in this country by Citröen-Kegresse creeper track car.

German Postal Administration. Auto Service of the German Postal Administration (Der Kraftwagenbetrieb der Reichspostverwaltung unter besonderer Berücksichtigung des Postreiseverkehrs), Hering. Archiv für Post und Telegraphie, no. 6, June 1922, pp. 173–197, 10 figs. Development of suburban and long-distance postal omnibus service, freight-transportation service, and telegraph construction service; describes automobiles used.

G. W. K. The G. W. K. Car. Auto, vol. 27, no. 29, July 20, 1922, pp. 595–598, 11 figs. Light car with friction drive.

Hotchkiss 18–22 Hp. The 18–22 Hp. Hotchkiss Car. Auto, vol. 27, no. 27, July 6, 1922, pp. 553–556, 13 figs. New model of Parisian vehicle; some modifications from previous design; transmission mechanism.

Light Cars. The Temperino Light Car. Auto, no. 26, vol. 27, June 29, 1922, pp. 533–535, 11 figs. Novel design combined with simplicity, lightness and low fuel consumption; 8-hp. twin-cylindered air-cooled engine.

Nazzaro. The 18–30 Hp. Nazzaro Car. Auto, vol. 27, no. 30, July 27, 1922, pp. 617–620, 11 figs. Italian model with overhead valve gear having supplementary rocker and spring, making operation noiseless.

Springs. See SPRINGS, Manufacture.

Streamline. Streamline Autos (Der Stromlinienwagen), P. Jaray. Motorwagen, vol. 25, no. 17, June 20, 1922, pp. 333–336, 7 figs. New type of construction to reduce air resistance; results of experiments made with it in Zeppelin wind tunnel; fuel consumption, etc.

The New Rumpler Chassis. Automobile Engr., vol. 12, no. 165, July 1922, pp. 194–203, 20 figs. Critical examination of new design; streamline type; six-cylinder engine, cylinders being cast in pairs and grouped fanwise above two-throw crankshaft.

Transmission Gears. Practical Difficulties in Automatic Transmission Gear Design, P. M. Heldt. Automotive Industries, vol. 47, no. 4, July 27, 1922, pp. 164–165, 1 fig. Describes Andreau gear consisting essentially of internal-type planetary gear with operation controlled by pair of centrifugal weights.

Wheels. Camber and Gather Relationships in Front-Wheel Alignment, J. C. Sproull. Soc. Automotive Engrs. Jl., vol. 11, no. 1, July 1922, pp. 91–92 and 116, 4 figs. Effect of tilting of wheel spindles so that wheels lean outward at top, and so as to bring front part of wheels nearer together than rear, and mathematical formulas for determining their proper values.

How Pressed Steel Wheels are Made, J. Edward Schipper. Automotive Industries, vol. 47, no. 2, July 13, 1922, pp. 71–74, 14 figs. Recent machine-tool developments add to manufacturing efficiency; varied nature of presswork shows wide possibilities in pressed-steel production; disk of tapered section is employed.

AVIATION

Aerial Navigation and Instruments. Aerial Navigation and Navigating Instruments, H. N. Eaton. Nat. Advisory Committee for Aeronautics, Report No. 131, 1922, 44 pp., 26 figs. Description of dead-reckoning method; natural and artificial horizons and radio direction finder.

Newfoundland and Labrador. Aviation in Newfoundland and Labrador. Aviation, vol. 13, no. 2, July 10, 1922, pp. 41–43, 3 figs. Practical demonstration of value of aerial mail and passenger transport in Arctic countries.

Safety. Safety in the Air. Aeroplane, vol. 22, no. 26, June 28, 1922, pp. 463–464. Dangers incident to starting, flying, and landing, and suggestions for minimizing same.

B

BALANCING

Rotating Parts. Balancing Rotating Parts (Sur l'équilibrage des pièces tournantes), C. Feru and J. Labouret. Révue Générale de l'Électricité, vol. 11, no. 25, June 24, 1922, pp. 919–926, 12 figs. Balancing on one and two bearings, determination of angle ϕ.

BALLISTICS

Exterior. Exterior Ballistics in Anti-Aircraft Firing and Their Industrial Applications (La balistique extérieure du tir aérien, applications industrielles), Gustave Lyon. Bul. de la Société d'Encouragement pour l'Industrie Nationale. vol. 134, no. 4, Apr. 1922, pp. 327–380, 32 figs. Discusses progress made during war in measuring and determination of trajectories, and describes in detail instruments used. Includes two appendices by Maurie Garnier.

BEAMS

Reinforced-Concrete. Chart for Rapid Calculation of the Minimum Iron Cross-Section in Reinforced-Concrete Beams Under Flexure and Compression or Tension (Graphique puor l'obtention rapide des sections de fer minima, dans une poutre en béton armé, soumise a des efforts composés de flexion avec compression ou tension), E. Gardiol. Bul. Technique de la Suisse Romande, vol. 48, no. 10, May 13, 1922, pp. 113–119, 5 figs. Develops formulas and explains use of chart.

T-Beams, Calculation. Charts for Calculating T-Beams Under Flexure (Abaque pour le calcul des poutres en T soumises à flexion simple), R. Coppee. Annales de l'Association des Ingénieures Sortis des Écoles Spéciales de Gand, vol. 12, no. 1, 1922, pp. 49–53, 2 figs. partly on supp. plate. Develops formulas and explains use of chart.

BEARING METALS

Car and Power-House. Metals for Car and Power House Bearings, H. H. Buckman. Elec. Ry. Jl., vol. 60, no. 2, July 8, 1922, pp. 47–48. Some essential characteristics of satisfactory bearing metal; advantages of using lead-base metal. (Abstract.) Paper read before Central Elec. Ry. Assn.

BEARINGS

Casting. Foundry Practice (La Pratique du Régulage), M. Verneret. Fonderie Moderne, nos. 4 and 5, Apr. and May 1922, pp. 97–99, and 143–152, 15 figs. Apr.: Operations connected with casting anti-friction metals direct on to bearing surfaces; nature and choice of anti-friction metals and alloys. May: Utilization of scrap; remelting of metal; fluxes and oxidizing agents; casting; etc.

BEARINGS, BALL

Design. Load on Ball Bearings (Kugelagrets Belastning), F. Symanzik. Teknisk Ukeblad, vol. 69, no. 23, June 9, 1922, pp. 216–218, 3 figs. New method for determining size of ball bearings; examples and calculations.

Flour-Mill Equipment. Saving Power in Minnesota Mill. Am. Miller, vol. 50, no. 7, July 1, 1922, pp. 719–720, 5 figs. Ball-bearing equipment of Hubbard Milling Co., Mankato; installation of SKF ball bearings on lineshafts which accomplished estimated saving of $3,250 first year.

Roller and. Ball and Roller Bearings in Street-Car Operation and Small Factories (Kugel- und Rollenlager im Strassen- und Kleinbetrieb), Carl Tobias. Zeit. des Österr. Ingenieur- u. Architekten-Vereines, vol. 74, nos. 11–12 and 15–16, Mar. 17 and Apr. 14, 1922, pp. 55–56, and 69–71, 5 figs. Mar. 17: Experiments with ball and roller bearings for railway rolling stock; lubrication and its relative cost. Apr. 14: Discusses advantages in saving of lubricants and attention.

BEARINGS, ROLLER

Design and Construction. Rolling Contact Bearings, Tobias Dantzig. Steam, vol. 30, no. 1, July 1922, pp. 3–7. Important requirements of efficiency, capacity, long life, operation at high speed, self-alignment, and ability to maintain permanent clearance. Means of attaining each. Read before Cincinnati Section A.S.M.E.

BLAST FURNACES

Sulphur Excess in Slag. Blast Furnaces Difficulties Due to Excessive Sulphur in Slag (Ueber noch wenig bekannte Schwierigkeiten im Hochofen durch "Schwefelelend"), A. Killing. Stahl u. Eisen, vol. 42, no. 25, June 22, 1922, pp. 968–971, 3 figs. Practical observations with sulphur-rich slag. Injurious effect of sulphur on blast-furnace process. Remedies.

BLOWERS

Blast-Furnace Centrifugal. Centrifugal Blast-Furnace Blowers. Iron & Coal Trades Rev., vol. 104, no. 2833, June 16, 1922, pp. 896–897, 5 figs. Turbo-blowers producing pressures up to 40 lb. per sq. in. and turbo-compressors for higher pressures both transform for energy, half into direct compression and half kinetic energy. Many blast-furnace requirements.

BOILER FEEDWATER

Treatment. A Criticism of the Various Methods of Purifying Feedwater (Kritik der verschiedenen Methoden der Reinigung von Kesselspeisewasser), B. Preu. Dinglers polytechnisches Jl., vol. 337, nos. 1 and 2, Jan. 14 and 29, 1922, pp. 1–4 and 11–13, Jan. 14: Reviews efficiency of lime-soda method, the permutite method, Neckar method, and others. Jan. 29: Describes new method by Ph. Müller and the apparatus, and calculates its efficiency.

Continuous Blowdown and Water Purification Process, M. Kestner. Power Plant Eng., vol. 26, no. 13, July 1, 1922, pp. 647–652, 10 figs. Method of precipitating impurities outside of boiler without loss of heat. (Abstract.) Paper read before British Inst. Mech. Engrs.

Softening of the Boiler Feedwater (Enthärtung des Kesselspeisewassers), P. Martiny. Archiv für Wärmewirtschaft, vol. 3, no. 6, June 1922, pp. 103–110, 7 figs. Action of carbonic acid and oxygen; formation of incrustation and its remedy; describes principal processes of treating water.

BOILER OPERATION

Firing With Low-Grade Fuels. Hints on Firing

With Low-Grade Fuels and Adapting Furnaces for Such Fuels (Winke zur Verheizung von minderwertigen Brennstoffen und zur Umstellung der Feureungen auf solche Brennstoffe), Schnell. Zeit. des Bayerischen Revisions-Vereins, vol. 26, no. 12, June 30, 1922, pp. 95–98. Temporary and permanent adaptation of furnaces of steam boilers of various types; ratio of grate surface to heating surface; mixture of fuels.

Grate Charge. Dependence of Grate Charge on Moisture Content of Fuel (Die Abhängigkeit der Rostbelastungen vom Wasserstoffgenalt des Brennstoffes), W. Viebahn. Braunkohle, vol. 21, no. 13, June 30, 1922, pp. 258–262, 3 figs. Discusses so-called grate load, i.e., number of kg. of fuel burned per hr. per sq. m. of grate surface, and discusses this load for lignite and coal containing different percentages of water.

Humidity and Barometric-Pressure Effects. Effect of Humidity and Barometric Pressure on Boiler Efficiency (Der Einfluss der Luftfeuchtigkeit und des Barometerstandes auf den Kesselwirkungsgrad), L. Finckh. Wärme, vol. 45, no. 23, June 9, 1922, pp. 283–285. Quantity and temperature of air for combustion for lignite, coal and peat; gives table of comparative figures.

[See also PEAT; PULVERIZED COAL, Boiler Firing.]

BOILERS

Electrically Heated. Regulating Electrode Steam Boilers (Die Leitungsregelung von Elektrodendampfkesseln), Edgar Zeulmann. Elektrotechnische Zeit., vol. 43, nos. 22 and 23, June 1 and 8, 1922, pp. 759–762 and 784–788, 27 figs. Describes best-known types of electrode steam boilers in which boiler water itself forms electric resistance, and gives their advantages and disadvantages, methods of regulation, etc.

Report on an Investigation of an Electric Boiler Installation (Bericht über die Untersuchung einer Elektrokesselanlage). Zeit. des Bayer. Revisions-Vereins, vol. 26, no. 10, May 31, 1922, pp. 85–86, 3 figs. Detailed description of boiler installation of a textile spinning and weaving establishment at Blaichach, working on 1000-kw. polyphase current at 510 volts, which has given entire satisfaction.

Maintenance. Recommendations on Boiler Maintenance, A. G. Pack. Ry. Jl., vol. 28, no. 8, Aug. 1922, pp. 19–21. Data from practical experience and suggestions. Welding employed where other means of construction could be more profitably employed. Author is chief inspector of locomotive boilers for U. S. Government.

Testing. The Question of Accurate Boiler Tests, Alfred Cotton. Power House, vol. 15, no. 14, July 20, 1922, pp. 17–20, 2 figs. Attempt to establish accuracy of tests; discussion of various items involved.

BRAKING

Freight-Train. Application of the Continuous Brake to Freight Trains in Tunis (Une application du frein continu aux trains de marchandises en Tunisie), Louis Tronchère. Révue Générale des Chemins de Fer et des Tramways, vol. 41, no. 1, July 1922, pp. 3–11, 4 figs. Describes tests made in 1909 by Gafsa Co. on Sfax-Redeyef line, and gives rules adopted for equipment and operation.

Regenerative. An Analysis of Regenerative Braking on Electric Locomotives, C. E. Fairburn and F. A. Harper. English Elec. Jl., vol. 2, no. 2, Apr.-July, pp. 68–77, 5 figs. Mathematical analysis, with curves.

BUILDING MATERIALS

Testing Machines. New Machines for Testing Building Material. Eng. Progress, vol. 3, no. 7, July 1922, pp. 157–158, 6 figs. Exhibition at last Spring Fair at Leipsic of testing machines for cement and other construction materials which have remarkable constructional features.

BUSES

Trolley. A New English Trolley Bus. Bus Transportation, vol. 1, no. 7, July 1922, pp. 379–380, 4 figs. Vehicle designed from experience with gasoline road vehicles; single motor is used and automatic control features are provided to facilitate quick acceleration. Easy coasting and safe operation generally.

Notes on Railless Electric Traction, E. M. Munro. Tramway & Ry. World, vol. 51, no. 29, June 15, 1922, pp. 287–295, 15 figs. Analysis of principles involved. Data from types of cars in daily service and comparison with tramcars and motor buses. Paper to be read at Congress of Tramways & Light Rys. Assn.

C

CAMS

Circumference Formula. Formula for Circumference of Portion of Cam. Machy. (Lond.), vol. 20, no. 513, July 27, 1922, pp. 524–525, 1 fig. Mathematical treatment.

CAR COUPLINGS

Screw, Railway. Railway Screw Couplings. Ry. Gaz., vol. 37, no. 2, July 14, 1922, pp. 61–62, 1 fig. Test results of nickel-chrome steel coupling for Bengal-Nagpur railway.

CAR LIGHTING

Electric. Principal Systems of Train Lighting (Les principaux systèmes d'éclairage électrique individual appliqués aux voitures de chemins de fer), M. Bougrier. Électrician, vol. 38, no. 1304, July 15, 1922, pp. 313–320, 7 figs. Describes electric systems by Stone, Vicarino, and Aichelé, and their apparatus and operation.

Train Lighting (L'Éclairage des trains), H. Guerin. Génie Civil, vol. 81, nos. 1, 2 and 3, July 1, 8 and 15, 1922, pp. 13–15, 36–40 and 59–63, 25 figs. Substitution of electric lighting for systems in use; development of train lighting and its general principles; Brown-Boveri, Dick-E. V. R., Vickers, Etat-E. V. R., Stone, Leitner, Electric Storage Battery Co., and Société de l'Éclairage des Véhicules sur Rails systems; various types of storage batteries.

CAR WHEELS

Chilled-Iron. Properties of Chilled Iron Car Wheels, George W. Lyndon. Elec. Traction, vol. 18, July 1922, no. 7, pp. 592–594, 2 figs. Association of manufacturers of chilled car wheels and Univ. of Ill. investigate wheel fit and static load strains. Bur. of Standards conducts tests on thermal stresses.

CARBURETORS

Adjustment by Gas Analysis. Carburator Adjustment by Gas Analysis, A. C. Fieldner and G. W. Jones. Jl. Indus. & Eng. Chem., vol. 14, no. 7, July 1922, pp. 594–600, 10 figs. Experimental work on determination of carbon dioxide in exhaust gas, which has direct bearing on carburetor adjustment.

Capac. A New Capac Carburetter. Autocar, vol. 49, no. 1397, July 28, 1922, p. 188, 1 fig. Instrument specially devised for sporting-car engine and to provide rapid acceleration.

CARS, FREIGHT

Gondola, C. M. & St. P. How the C. M. & St. P. R. R. Designed Their New Gondola Cars. Ry. Rev., vol. 70, no. 23, June 10, 1922, pp. 834–841, 11 figs. Analysis of functions of individual members and calculation of stresses involved.

Springs. Spring Assemblages for Freight Car Trucks, Geo. S. Chiles. Ry. Rev., vol. 70, no. 23, June 10, 1922, pp. 844–850, 8 figs. New side frame and bolster design provides higher spring capacity and lower truck weight.

CARS, PASSENGER

6-Wheel Cast-Steel Truck. The Latest Development in 6-Wheel Passenger Trucks. Ry. Rev., vol. 70, no. 23, June 10, 1922, pp. 831–833, 6 figs. Pullman Company adopts new design of commercial type with clasp-brake equipment.

CASE-HARDENING

Steels for. A Comparison of the Rate of Penetration of Carbon into Various Commercial Steels in Use for Case Carburizing, S. C. Spalding. Am. Soc. for Steel Treating Trans., vol. 2, no. 11, Aug. 1922, pp. 950–976, 136 figs. Investigation of straight carbon, chromium-silicomanganese, nickel, chromium, nickel and chromium-molybdenum steels. Curves and photomicrographs.

CAST IRON

Testing Methods. New Methods of Testing Cast Iron, E. V. Ronceray. Metal Industry (Lond.), vol. 20, no. 25, and vol. 21, no. 1, June 23 and July 7, 1922, pp. 586–588 and 13–18, 20 figs. Review of various methods and description of work of Fremont's transverse testing machine. Paper read before Inst. British Foundrymen.

New Methods of Testing Cast Iron, E. V. Ronceray. Foundry Trade Jl., vol. 26, no. 307, July 6, 1922, pp. 5–12, 19 figs. Fremont's transverse testing machine; shearing tests; M. Portevin's test; elastic limit, modulus of elasticity, sounding and ball tests.

CEMENT MANUFACTURE

Electric. Electric Cement, Henry J. Harms, Jr. Concrete, vol. 20, no. 6, June 1922, pp. 113–115. Description of French process for producing cement in an electric furnace; superiority of product.

Iron and Steel Application. Iron and Steel Application to the Cement Industry, W. R. Shimer. Eng. World, vol. 21, no. 2, Aug. 1922, pp. 93–96. Selection of steels for use in handling cement, particularly heat-treated steel for shovels, gyratories.

CENTRAL STATIONS

France. The Great Thermoelectric Central Station at Comines [La grande centrale thermoélectrique de Comines (Nord)], J. Reyval. Révue Générale de l'Electricité, vol. 12, nos. 2 and 3, July 15 and 22, 1922, pp. 55–68 and 93–105, 34 figs. July 15: One of the most modern stations; has three 25,000-kw. units giving normal power of 50,000-kw., one unit being spare; describes boiler house, machine room and equipment. July 22: Describes pumping station and water intake, 45,000-v. transmission lines, overhead equipment, and underground equipment.

Superpower. The Bavarian Works and Its Sources of Power (Das Bayernwerk und seine Kraftquellen), A. Menge. Elektrotechnische Zeit., special no. May 28, 1922, pp. 2–20, 30 figs. Object of this works is to supply whole of Bavaria with electric power as economically as possible and for this purpose a 110-kv. transmission line has been built, connecting up Munich, Meitingen, Nurenberg, Amberg, Regensburg and Landshut lines; describes masts, insulators, general line equipment, transformers, and switching systems.

The Gennevilliers Central Station [La centrale électrique de Gennevilliers (Seine)], Ch. Dantin. Génie Civil, vol. 81, no. 1, July 1, 1922, pp. 1–13, 33 figs. partly on supp. plates. Has 5 groups of turbo-alternators of 40,000 kw. each and 3 in reserve, making total of 320,000 kw. Describes buildings, boiler house, stoking, ash handling, turbines and alternators, high-tension cables, switchboards, etc.

CERIUM

Effect on Brass and Iron. Adds Cerium to Brass and Iron, L. W. Spring. Foundry, vol. 50, no. 13, July 1, 1922, pp. 542–544, 2 figs. Effect on red brass is to increase percentage of leaky castings and lower tensile strength and ductility. Shows marked effect on converter steel and causes gray iron to feed better. Paper prepared for convention of Am. Foundrymen's Assn.

CHROMIUM STEEL

Chromium Determination. Rapid Methods for the Determination of Chromium in Steel, A. S. Townsend. Forging & Heat Treating, vol. 8, no. 7, July 1922, pp. 304–305. Oxidation of chromium in acid solution to chromic acid; bibliography.

COAL

Briquetting. Briquetting of Dutch-Indian Coal and Lignite (Briketteering van Indische steen- en bruinkolen), A. Guyot van der Ham. Ingenieur, vol. 37, no. 27, July 8, 1922, pp. 515–523 and (discussion), 523–626, 1 fig. Methods and operations of Sawah Loento briquetting factory, using pitch as binding medium.

Drying. Hoyle Centrifugal Dryer at Tinsley Park Coke Ovens. Colliery Guardian, vol. 123, no. 3209, June 30, 1922, p. 1603, 2 figs. Apparatus in which coal flung outward by centrifugal force against screens passes down as thin film on inner surfaces of screen while moisture goes through.

COAL HANDLING

Ash and. Economical Handling of Coal and Ashes, Henry J. Edsall. Can. Manufacturer, vol. 42, no. 7, July 1922, pp. 23–26, 2 figs. Great savings made from installations and recent developments.

Modern Coal and Ash Handling Plant. Gas Engr., vol. 38, no. 554, June 15, 1922, pp. 155–158, 9 figs. Advantages and disadvantages of various types and general points for consideration.

Pneumatic. The Pneumatic Handling of Coal, H. Blyth. Gas Engr., vol. 38, no. 554, June 15, 1922, pp. 151–154, 5 figs. Conditions under which satisfactory results may be expected and details of successful installation.

COLD STORAGE

Research Laboratory. Cold Storage Research Laboratory. Ice & Refrigeration, vol. 63, no. 2, Aug. 1922, pp. 93–97, 6 figs. Description of laboratory at Canton, Pa., established for purpose of carrying on experiments and research work in storage of perishable products.

COKE

Analysis. The Analysis of Coke, Arthur Grounds. Iron & Coal Trades Rev., vol. 104, no. 2835, June 30, 1922, p. 977. Sampling, moisture, ash, sulphur, phosphorus, calorific value.

Economy for Steam Fuel. Economy of Coke for Steam Fuel. Gas Age-Rec., vol. 50, no. 4, July 22, 1922, pp. 107–108. Coke at $6 cheaper if properly burned for steam raising than coal at $7.

COKE MANUFACTURE

Metallurgical. Production of Metallurgical Coke (Die Erzeugung von Hüttenkoks aus nicht backenden Kohlen), M. Dolch. Glückauf, vol. 58, no. 25, June 24, 1922, pp. 772–776. Experiments for producing good coke from coal which cakes poorly or not at all.

Non-Coking Coals. Good Coke Now Manufactured from Non-Coking Coals of Illinois, with Saving of Byproducts, H. A. Patterson. Coal Age, vol. 22, no. 2, July 13, 1922, pp. 45–50, 5 figs. Seeks to coke coal before cementing material is oxidized; heat graduated to suit thickness of bed to be coked; coking time lowered to twelve hours; gas introduced at two levels. (Abstract.) Paper read before Ill. Min. Inst.

Theory. A Recent Theory of Coking, F. V. Tideswell. Fuel in Science & Practice, vol. 123, no. 3208, June 23, 1922, pp. 101–103. Discussion of theory underlying improved process which claims to include bituminous and non-bituminous non-coking coals in coking coals.

COKE OVENS

Heating with Blue Water Gas. Heating Coke Ovens with Blue Water-Gas, J. F. O'Malley. Chem. & Met. Eng., vol. 27, no. 2, July 12, 1922, pp. 75–78, 6 figs. Doubles surplus gas from ovens; eliminates carbon from heating flues and permits uniform oven operation without change of burners.

Path of Gas Travel. The Foxwell Theory of the Path of Travel of the Gases in the Coke Oven, Gas World, vol. 76, no. 1976, June 3, 1922, p. 10, 1 fig. Laws controlling path found to be similar to those for nest of capillary tubes. Discussion of application of theory.

COMBUSTION

Gas Distribution. Study of Distribution of Combustion Gases. Am. Gas Jl., vol. 117, no. 5, July 29, 1922, pp. 89–91, 7 figs. Description of new method of studying diffusion of heat in various apparatus and distribution of combustion gases by means of properties of colored smoke. Model tests compared with phenomena in apparatus in actual operation. From "High-Pressure Boilers" by H. Thoma, Berlin.

Spontaneous. Spontaneous Combustion, Walter L. Wedger. Safety, vol. 9, no. 7, July 1922, pp. 163–168, 1 fig. Various causes and attempts at prevention. Apparatus for testing tendency of cloth. From paper read before Mass. Safety Council of Nat. Safety Council.

COMPASSES

Gyroscopic. Theory of the Gyroscopic Compass (Théorie du compas gyroscopique), P. Lemaire. Technique Moderne, vol. 14, no. 5, May 1922, pp. 202–205, 2 figs. Describes construction and operation and makes calculations in connection with it.

COMPRESSED AIR

Storage. Compressed-Air Power Storage (Kraft-Speicherungs-Anlagen mittels komprimierter Luft), W. E. Trümpler. Schweizerische Bauzeitung, vol. 79, no. 17, Apr. 29, 1922, pp. 222–224, 7 figs. Discusses pneumatic accumulation in place of hydraulic accumulation by compressing air into heat-insulated storage tanks ready for any power use.

CONDENSERS, STEAM

Design. Steam Condensing Plant, D. L. Hall. Beama, vol. 10, no. 6, June 1922, pp. 427–436, 4 figs. Items to which careful consideration must be given in designing surface condensers and jet condensers; air leakage and air pumps; condensate pump; plant arrangement.

CONVEYORS

Belt. Essentials of a Serviceable Belt Conveyor, Omega. Eng. & Indus. Management, vol. 7, no. 18, July 13, 1922, pp. 585–589, 9 figs. Notes on design and various elements.

Cotton Mill. Conveyors at Great Falls Manufacturing Company, Ernest Fallows. Textile World, vol. 62, no. 1, July 1, 1922, pp. 67 and 69, 5 figs. Equipment installed for mechanical handling of stock in new 5-story concrete cotton mill at Somersworth, N. H. Advantages are shown in labor saving and better condition of material during manufacture.

CORROSION

Prevention. Fighting Corrosion as a Major Source of Waste in Industry, R. H. Hubbell. Jl. Elec. & West. Industry, vol. 49, no. 1, July 1, 1922, pp. 9–11, 7 figs. Choice of proper coating; paints that injure metal.

Mechanism of Metallic Oxidation at High Temperatures, N. B. Pilling and R. E. Bedworth. Chem. & Met. Eng., vol. 27, no. 2, July 12, 1922, pp. 72–74. Rapidity due to combination of physical properties of oxide and its ability to absorb and diffuse oxygen rather than to any property of metal itself. Paper read before Am. Inst. Min. & Metallurgical Engrs.

Oxidation of Steels and Their Use in Degasification of Water (Sur l'oxydabilité des aciers et leur utilisation au dégazage de l'eau), G. Paris. Chaleur et Industrie, vol. 3, no. 25, May 1922, pp. 1259–1261, 1 fig. Discusses dependence of oxidation of steels on their crystalline structure, and proposes special alloys for fixing oxygen in water.

CRANES

Ship. The New Ship Crane for the Navy, A. F. Case. Tech. Eng. News, vol. 3, no. 3, June 1922, pp. 71, 85, 88 and 94, 2 figs. Contract has been awarded by Navy for construction of 250-ton revolving crane, to be mounted on U. S. battleship Kearsarge; largest sea-going crane ever constructed.

Slewing. Slewing Cranes (Grues roulantes et pivotantes sur portique). Bul. Technique de la Suisse Romande, vol. 48, no. 15, July 20, 1922, pp. 174–178, 2 figs. Describes electrically driven crane for dock purposes with 50-ton per hr. capacity and 4500 kg. load.

Traveling. Lifting Apparatus (Appareils de levage), Legrand-Ribet. Outillage, vol. 6, nos. 24 and 25, June 17 and 24, 1922, pp. 765–767, and 787–791, 9 figs. June 17: Calculations and specifications of an electric traveling crane of 10,000 kg. capacity at 20 m. radius of action, with hoisting speed of 6 m. per min. June 24: Describes framework of crane and calculations for it.

CRANKSHAFTS

Manufacture. Making the Marmon Crankshaft, Fred B. Jacobs. Abrasive Industry, vol. 3, no. 7, July 1922, pp. 199–204, 10 figs. Accuracy and quantity production are assured by modern grinding machines and abrasive wheels; shafts must be balanced accurately.

CUTTING TOOLS

See ALLOYS, Diamond.

CYLINDERS

Automobile, Casting. Casting Chevrolet Cylinders. Foundry, vol. 50, no. 14, July 15, 1922, pp. 565–569 and 579, 6 figs. Details of core making, venting, method of setting and adjusting cores, together with general features involved in making mold; equipment is adequate.

D

DIES

Self-Opening, Chasers for. Making Chasers for Self-opening Dies. Am. Mach. Vol. 57, No. 5, Aug. 3, 1922, pp. 169–174, 16 figs. Milling blocks to form and size; cutting threads by means of hobs; hand and machine tapping methods.

DIESEL ENGINES

Design. Variations in Modern Diesel-Engine Design, Thos. Orchard Lisle. Soc. Automotive Engrs. Jl., vol. 11, no. 1, July 1922, pp. 92–106, 36 figs. Unfavorable comments on tendency to depart from original Diesel designs.

Fuel Oil, High-Viscosity. Boiler-Oils for Diesel Power, L. B. Jackson. Motorship, vol. 7, no. 7, July 1922, pp. 528–530, 4 figs. Valuable development work in use of fuel oils for motorships carried out by Texas Co.

Valves. Care of Valves on Diesel Engines, L. R. Ford. Power, vol. 56, no. 6, Aug. 8, 1922, pp. 204–206, 4 figs. General discussion.

Werkspoor. British Construction of Werkspoor Diesel Engines. Motorship, vol. 7, no. 8, Aug. 1922, pp. 607–612, 8 figs. Motors built by North Eastern Mar. Eng. Co. for single-screw fruit-carrying vessels, Segona and Seville.

DIRECTION FINDERS

Navigation. Radio Direction Finding, F. W. Dunmore. Pacific Mar. Rev., vol. 19, no. 7, July 1922, pp. 404–407. Methods of radio direction finding as aid to navigation; relative advantages of locating finder on shore and on shipboard.

DRILLING MACHINES

Design. Effect of Design on Drilling Machine Efficiency, F. E. Johnson. Machy. (N. Y.), vol. 28, no. 12, Aug. 1922, pp. 964–967, 6 figs. Important factors in design and operation. Suggestions for improving operative conditions.

DUST

Collection. Designing a Dust-Collecting System, H. M. Nichols. Wood Worker, vol. 41, no. 4, June 1922, pp. 50–51. Principles which must be considered in planning efficient exhaust system for woodworking plant.

Explosions. Progress in Dust-Explosion Prevention, David J. Price. Chem. & Met. Eng., vol. 26, no. 26, June 28, 1922, pp. 1203–1206. Flour-milling industry and dust explosions; Federal investigation of dust explosions; summary of dust-explosion losses in various industries; progress of dust collection and removal and adoption of methods of preventing explosions. Paper read at Millers' Federation Mass. Convention.

DYE INDUSTRY

Synthetic. Development of the Synthetic Dye Industry (Le développement de l'Industrie des colorants synthétiques), Eug. Grandmougin. Génie Civil, vol. 80, nos. 22, 23 and 24, June 3, 10 and 17, 1922, pp. 491–494, 517–520, and 543–546. June 3: Development in France; prime materials; intermediates andt heir production; production of dyes themselves. June 10: Short history of dye industry; production of dyes in various countries. June 17: Future of dye industry generally and of scientific research in connection with it.

DYNAMOMETERS

Brake. Measuring Electric Power by the Brake Dynamometer (Mesure de la puissance des moteurs électriques au moyen des dynamos dynamomètres), M. Marre. Électricien, vol. 53, no. 1300, May 15, 1922, pp. 222–227, 8 figs. Construction and operation of brake dynamometer, its application in testing, friction losses, etc.

E

ECONOMIZERS

Performance. Notes on Economizer Performance, A. W. Binns. Power Plant Eng., vol. 26, no. 14, July 15, 1922, pp. 694–697, 5 figs. Losses, methods of testing, obtaining standards and maintenance.

ELECTRIC FURNACES

Brass and Bronze. Electric Melting Furnaces for Brass and Bronze, Howard McLean and John M. Boyd. West. Machy. World, vol. 13, no. 7, July 1922, pp. 244–246, 4 figs. Commercial uses for electric furnace and description of various types; some considerations of comparative melting costs.

Enameling, Vitreous. Developments in 1921 in Electric Vitreous Enameling Furnaces, James W. Carpenter. Am. Ceramic Soc. Jl., vol. 5, no. 7, July 1922, pp. 409–419, 4 figs. Summary of new installations in 1921 and description of various types of furnaces; operating data.

Resistance. Wire and Ribbon Wound Resistance Furnaces, Charles C. Bidwell. Sibley Jl. of Eng., vol. 36, no. 6, June 1922, pp. 119–121 and 129. Temperature range determines choice of resistor refractory and thermal insulation; temperature distribution determines shape of furnace, manner of winding, heating elements and placing thermal insulation.

Single-Phase. Single-Phase Electric Furnace, H. P. Abel, A. A. Liardet and W. West. Iron & Steel of Canada, vol. 5, no. 7, July 1922, pp. 128–130. Advantages of single-phase furnaces; drawback of bad effect of power factors; details of construction and operation.

Steel. A New French Electric Furnace for Steel Foundry, R. Sylvany. Can. Foundryman, vol. 13, no. 7, July 1922, pp. 28–29. Constructed with idea of insuring good purification by direct passage and uniform distribution of current through metal and slag.

Fiat Electric Steel Furnace, Dr. Alfredo Stromboli. Chem. & Met. Eng., vol. 27, no. 1, July 5, 1922, pp. 28–30, 5 figs. Description of Fiat furnace of large output with tight roof maintained by special economizer.

The New Electric Steel Furnaces of the Fiat Works (Die neuen Elektrostahlöfen der Fiat-Werke), G. Vitali. Stahl u. Eisen, vol. 42, no. 24, June 15, 1922, pp. 921–924, 6 figs. General adoption of electric steel furnaces; principles of Fiat furnace, its construction, including electrodes, control of operations, and results of working.

Sweden. Electric Smelting and Blast-Furnace Installations in Porjus (Sweden) (De elektriska smältverks- och masugnasnläggningarna i Porjus), Gumnar Herlin. Jernkontorets Annaler, vol. 106, no. 4, 1922, pp. 99–132, 22 figs. Detailed description of plant layout, buildings, electrical and other equipment, furnaces, etc.

ELECTRIC LOCOMOTIVES

Swiss. Single-Phase Express Locomotives 2-C-1 With Individual Axle Drive of the Brown-Boveri Type (Einphasen-Schnellzuglokomotiven 2-C-1 mit Einzelachsantrieb Bauart Brown Boveri). Schweizerische Bauzeitung, vol. 80, no. 2, July 8, 1922, pp. 13–17, 12 figs. partly on supp. plate. Describes locomotives of Swiss federal railways, including distribution of weight, individual axle drive, cogwheel arrangement, etc.

2-8-2 Mikado. New Electric Locomotives of the Orleans Railway (Nouvelles locomotives électriques du chemin de fer d'Orléans). Industrie Électrique, vol. 31, no. 718, May 25, 1922, pp. 185–188, 2 figs. Describes new 2-8-2 or Mikado type; 2,000 hp., d.c. at 250 v.; constructed by Electro-Mecanique Co. for Paris-Orléans railway.

ELECTRIC RAILWAYS

Austria. Electric Working of Austrian Railways (Der elektrische Betrieb auf den Oesterreichischen Bundesbahnen), E. E. Seefehlner. Elektrotechnische Zeit., special no., May 28, 1922, pp. 41–44, 5 figs. Discusses hydroelectric developments and describes new single-phase a.c. locomotives 1C + C1.

Germany. Electric Long-Distance Trains of the German State Railways (Mitteilungen aus dem elektrischen Fernzugbetrieb der Deutschen Reichsbahn), W. Wechmann. Elektrotechnische Zeit., vol. 43, nos. 24, 25 and 27, June 15, 22 and July 17, 1922, pp. 805–810, 837–840, and 904–908, 33 figs. Reviews electric traction on German railways; type of current; economics of electrification; results of electric operating of Silesian mountain railways; standardization of locomotives and their control; describes various types of locomotives; compares performance of steam and electric locomotives.

Electric Railroad Communication in Bavaria (Die elektrische Zugförderung im bayerischen Abschnitt der Reichsbahn), B. Gleichmann. Elektrotechnische Zeit., special no., May 28, 1922, pp. 24–32, 14 figs. Discusses railroad agreement between Prussian, Bavarian and Baden roads, traffic conditions, and gives particulars as to electric locomotives used.

Napa Valley, California. The Napa Valley Route. Elec. Ry. Jl., vol. 60, no. 1, July 1, 1922, pp. 7–8, 5 figs. San Francisco, Napa & Calistoga Ry. is successful single-phase California electric system; in connection with boat line it offers through service to San Francisco.

Temperature Effect on Power Consumption. Relation Between Temperature and Power Used by Electric Cars, A. W. Baumgarten. Elec. Ry. Jl., vol. 60, no. 3, July 15, 1922, pp. 77–78, 3 figs. Tests indicate that more power is used during cold weather; present methods of lubrication appear to be responsible for large part of increase.

ELECTRIC WELDING

Electropercussive. Review of Electro-Percussive Welding, D. F. Miner. Am. Welding Soc. Jl., vol. 1, no. 7, July 1922, pp. 27–36, 36 figs. Description of process and examples of welding.

Theories. Theories of Electric Welding. Practical Engr., vol. 66, no. 1845, July 6, 1922, pp. 5–6. Electrodes of future; carbon; brittleness; harmful elements.

ELECTRIC WELDING, ARC

Cyc-arc. The "Cyc-arc" Process of Automatic Electric Welding in Ship Work, L. J. Steele and H. Martin. Electrician, vol. 89, no. 2306, July 28, 1922, pp. 98–99, 3 figs. Recent developments. Success in making mild-steel welds.

Monel Metal. Arc Welding Monel Metal, P. D. Merica and J. G. Schoener. Welding Engr., vol. 7, no. 7, July 1922, pp. 42–44 and 46, 6 figs. Use of metallic deoxidizers has resulted in sound, strong, and moderately ductile welds. From paper read before Am. Welding Soc.

EMERY PAPER

Manufacture. Improving Emery Paper (Metod för förbättring av smärgelpapper), C. Benedicks and E. Sörberg. Jerkontorets Annaler, vol. 106, no. 5, 1922, pp. 178–185, 10 figs. Describes production under pressure and gives results obtained.

ENGINEERING SCHOOLS

Curricula, Criticism of. Engineering Schools Fall Short of Modern Needs, John H. Dunlap. Eng. News-Rec., vol. 89, no. 6, August 10, 1922, pp. 224–226. Criticisms of present methods; suggests longer course for engineering degree. Author is secretary of Am. Soc. Civil Engrs.

ENGINEHOUSES

Concrete-Unit. Concrete-Unit Roundhouses on the Pennsylvania R. R. Eng. News-Rec., vol. 89, no. 3, July 20, 1922, pp. 110–112, 3 figs. Large buildings framed of precast members; walls of brick and steel sash; casting yard and unit erection methods.

Southern Pacific. Southern Pacific Builds Unique Engine Houses. Ry. Age, vol. 73, no. 3, July 15, 1922, pp. 105–106, 2 figs. Rectangular concrete structures are provided with lead tracks at each end to expedite use.

EVAPORATION

Problems. The General Problem of Evaporation, J. W. Hinchley. Soc. Chem. Industry Jl., vol. 41, no 14, July 31, 1922, pp. 242T–246T, 3 figs. Study

of evaporation below boiling point of liquid evaporated and evaporation at boiling point.

EXTRUSION OF METALS

Process. Extrusion of Metals (Quelques lois expérimentales de l'écrouissage), L. Poitrinal. Technique Moderne, vol. 14, no. 5, May 1922, pp. 193–199, 6 figs. Different ways of deformation; determination of parameters required; extrusion by compression, traction, and compression and traction simultaneously.

F

FACTORIES

Location. Industrial Plants and Their Location, F. Theo. Gnaedinger. Eng. Inst. Canada Jl., vol. 5, no. 7, July 1922, pp. 354–358, 4 figs. General survey of principal features to be considered in locating, designing and constructing industrial plant.

Protection Against Loss and Theft. Protecting Industrial Plants and Contents Against Loss and Theft, Joseph Mayhew. Management Eng., vol. 3, no. 2, Aug. 1922, pp. 109–110. Loss and theft from within industrial organization; responsibility of management; example of systematic leakage.

FANS

Tests. Fan Testing (Undersökelse av Ventilatorer), Johan Grönningsaeter. Teknisk Ukeblad, vol. 69, nos. 18, 19 and 21, May 5, 12 and 26, 1922, pp. 159–163, 170–174 and 195–198, 26 figs. May 5: Results of tests of fans carried out at Norwegian Technical High School during 1919. May 12: Tests with torpedo-boat fan equipment. May 26: Tests with Sirocco fans.

FATIGUE

Industrial. Fatigue in Industry (Le Problème de la fatigue dans l'Industrie). Jean Waldsburger. Vie Technique et Industrielle, vol. 3, nos. 31 and 32, Apr. and May 1922, pp. 25–27 and 95–97, 5 figs. Apr.: Research work of Prof. Kent, in England, on study of fatigue in men and women workers, and instruments used for measurements. May: Research work of J.-M. Lahy, in France.

FEEDWATER HEATERS

Locomotive. Practical Advantages of Locomotive Feed Water Heating. Ry. Rev., vol. 70, no. 23, June 10, 1922, pp. 825–830, 6 figs. Maintenance and operation of locomotive feedwater heaters on 14 railroads. Int. Ry. Fuel Assn. report.

FIRE FIGHTING

Chemicals for. Chemicals Met with in Fire Fighting, Raymond Szymanowitz. Fire & Water Eng., vol. 71, no. 22, May 31, 1922, pp. 987–988 and 1006. Showing forms, qualities and reactions under influence of heat and water of all such substances; knowledge needed to intelligently handle chemical fires.

FIRE PREVENTION

Water Works Coöperation. How the Water Works Should Aid in Fire Fighting, Clarence Goldsmith. Fire & Water Eng., vol. 72, no. 1, July 5, 1922, pp. 7–8. Suggestions as to active coöperation between water and fire departments; water-works employees should answer alarms; hydrant inspection; matter of adequate pressure.

FIRECLAYS

Eastern Kentucky. Fire Clays of the Eastern Coal-field of Kentucky, H. Ries. Am. Ceramic Soc. Jl., vol. 5, no. 7, July 1922, pp. 397–408, 6 figs. Flint, semi-flint and plastic clay of real commercial value and geological analysis of occurrence.

FLIGHT

Soaring. An Explanation of Soaring Flight, J. W. Miller. Aviation, vol. 13, no. 5, July 31, 1922, pp. 121–123, 5 figs. Elementary theory. Condensed outline of series of lectures before Northwest Aeronautical Soc.

Soaring Flight and Its Mechanical Solution, F. W. Ruben. Aviation, vol. 12, no. 26, June 26, 1922, pp. 750–752, 5 figs. Observation of bird flight discloses ability of birds to vary their wing area with changing wind pressure.

FLOUR MILLS

Diesel-Engine Drive. The Dittlinger Mills, John Pierce. Power Plant Eng., vol. 26, no. 13, July 1, 1922, pp. 652–655, 5 figs. Description of Diesel-engine plant in flour mill at New Braunfels, Tex. Engine 225 hp.

FLOW OF WATER

Measurement. Methods and Apparatus for the Photometric Gaging of the Flow of Water (Procédés et appareillage pour le jaugeage photométrique de faibles cours d'eau), Paul P. E. Papadopoulo-Santo Rini. Annales de l'Energie, vol. 2, no. 3, May-June 1922, pp. 97–101, 11 figs. Describes method consisting of introduction of liquid color at one point and photometric determination of color on water at a given distance at a certain time.

The California Pipe Method of Water Measurement, Blake R. Vanleer. Eng. News-Rec., vol. 89, no. 5, Aug. 3, 1922, pp. 190–192, 3 figs. Description of apparatus used and its operation; tables and charts employed.

FLUE-GAS ANALYSIS

Apparatus for. A New Flue Gas Tester, Max Moeller. Eng. Progress, vol. 3, no. 7, July 1922, pp. 151–152, 3 figs. Instrument based on variation in heat conductivity of flue gases produced by alteration of CO_2 content by electrical means.

Automatic Carbon Dioxide Indicator for Flue Gas, R. B. MacMullin. Jl. Indus. & Eng. Chem., vol. 14, no. 7, July 1922, pp. 628–629, 2 figs. Description of instrument accurate to 0.02 per cent, which will record continuously for two days or more without need of refilling scrubber or readjusting zero point.

FLUE GASES

Movement. New Theory on the Movement of Flue Gases (Étude théorique nouvelle relative au mouvement spontané des gaz d'un courant de chauffage), H. Tripier. Chaleur et Industrie, vol. 3, nos. 25 and 26, May and June 1922, pp. 1244–1250, and 1360–1367, 10 figs. Discusses draft in stack, and losses connected with it, on basis of Bernoulli formula. Develops other formulas and methods of practical calculation, which are more general and more exact.

FORGINGS

Brass. Brass Forgings, C. G. Heiby. Metal Industry (Lond.), vol. 21, no. 2, July 14, 1922, pp. 25–27. Description of process; sand-cast blanks; chill-cast blanks; composition of metal; physical properties.

Hammers, Pneumatic. "Single-Blow" Pneumatic Forging Hammers, W. H. Snow. Engineering, vol. 114, no. 2952, July 28, 1922, pp. 98–101, 9 figs. Discussion of efficiency of operation, special reference to weight and duration of blow.

Steel for. Scientific Selection of Materials for Forgings. Am. Mach., vol. 57, no. 6, Aug. 10, 1922, pp. 211–215, 10 figs. Selection of steel; its testing and heat treatment.

FOUNDRIES

Compressed Air in. Compressed Air in the Foundry, L. W. Schnitzer. Compressed Air Mag., vol. 27, no. 7, July 1922, pp. 185–188, 8 figs. Pneumatic devices perform many useful operations in foundry; reduce costs and increase production.

Layout. Modern Tendencies in Foundry Installation (Tendances modernes présidant à l'Installation des Fonderies), M. Thomas. Fonderie Moderne, no. 5, May 1922, pp. 129–141, 4 figs. Foundries for heavy, medium, and mechanical castings; foundry sand; etc.

Malleable-Iron. Brass Firm Makes Malleables, Pat Dwyer. Foundry, vol. 50, no. 13, July 1, 1922, pp. 523–528, 10 figs. Powdered-coal equipment for annealing and core ovens; 100,000 sq. ft. of floor space and all modern improvements in sanitation, safety devices, dust exhaust system, etc.

Planning a New Malleable Shop, E. Touceda. Iron Trade Rev., vol. 71, no. 4, July 27, 1922, pp. 243–248, 3 figs. Consideration governing site selection and plant layout; design of equipment. (Abstract.) Exchange paper before Instn. British Foundrymen.

Safety. Safety Work in Foundries, R. W. Patmore. Metal Industry (Lond.), vol. 20, no. 25, and vol. 21, no. 1, June 23 and July 7, 1922, pp. 584–585 and 3–4. Also Foundry Trade Journal, vol. 25, no. 305, June 22, 1922, pp. 464–467. Analysis of causes of major and minor accidents in foundry and suggestions for campaign to reduce practice of same. Presented at Inst. British Foundrymen.

FRAMES

Kinematic Theory of. Kinematic Theory of Framework (Théorie cinématique du treillis), Léon Legens. Génie Civil, vol. 81, no. 2, July 8, 1922, pp. 40–43, 18 figs. Develops formulas and makes calculations.

FUEL ECONOMY

Power Plants. Fuel Economy in Steam Power Plants, John B. C. Kershaw. Beama, vol. 11, no. 1, July 1922, pp. 474–481, 3 figs. Composition and constitution of natural and artificial fuels, and chemistry of combustion process.

Fuel Economy and Production Expenses, Allen M. Perry. Elec. World, vol. 80, no. 3, July 15, 1922, pp. 115–118. Data given for electric plants burning coal, oil, gas and hogged fuel; careful analysis of data permits interesting comparisons between results obtained.

FUELS

Garbage. Burning Garbage Under the Boiler (Die Verwertung von Müll durch Verbrennung), H. Hermann. Gesundheits-Ingenieur, vol. 45, nos. 21 and 26, May 27 and June 30, 1922, pp. 274–278 and 339–343, 12 figs. May 27: Furnaces fired with garbage and other refuse, especially for hot water and heating purposes. June 30: Garbage incinerating plants, their operation and equipment.

Sawdust. Sawdust as Fuel. Elec. Rev., vol. 89, no. 2282, Aug. 19, 1922, pp. 236–238, 8 figs. Details of plant installed by John Sadd & Sons, Ltd., Maldon, Essex, for production of gas from sawdust.

[See also COAL; COKE; OIL FUEL; PEAT; PULVERIZED COAL.]

FURNACES, HEAT-TREATING

Continuous. Continous Furnaces and Their Application, P. J. Myall and L. A. Mekler. Forging & Heat Treating, vol. 8, no. 7, July 1922, pp. 322–326, 5 figs. Classification of continuous furnaces; type of furnace recommended for various operations; writers believe there should be ten continuous furnaces for one now in operation.

Scale Formation. Furnace Atmospheres and Their Relation to the Formation of Scale, George C. McCormick. Am. Soc. for Steel Treating Trans., vol. 2, no. 11, Aug. 1922, pp. 1006–1012, 3 figs. Experimental data and procedure during investigation of scaling activity of oxidizing, neutral and reducing atmospheres during heat treatment of steel.

FURNACES, BOILER

Air Preheaters. Air Preheaters for Boiler Furnaces. Engineering, vol. 114, no. 2949, July 7, 1922, pp. 24–27, 10 figs. Description of apparatus built by Ljungström Steam Turbine Co.

FURNACES, METALLURGICAL

Aluminum-Melting. Aluminum and Aluminum-Alloy Melting Furnaces, Robt. J. Anderson. Can. Foundryman, vol. 13, no. 7, July 1922, pp. 19–23, 3 figs. Review of work undertaken by U. S. Bur. Mines to decrease metal and fuel losses in melting.

G

GALVANIZING

Weight of Coating. Determination of Spelter Coating on Sheets, D. M. Strickland. Raw Material, vol. 5, no. 6, July 1922, pp. 227–228, 1 fig. Simple and accurate method which may be applied to all shapes and sizes of specimens. Portable equipment for field tests. Paper read at annual mtg. Am. Soc. for Testing Mtls.

GAS ENGINES

Blast-Furnace Gas. The Nurnberg Gas Engine (Die Nürnberger Gasmaschine), J. Schmidt. Elektrotechnischer Anzeiger, vol. 39, nos. 72, 73 and 74, May 6, 9 and 10, 1922, pp. 601–602, 613–614 and 619–620, 5 figs. Describes 4-stroke, two-cylinder tandem engine, 700 hp. at 125 r.p.m. (normal size 2,000 hp.), for more economic utilization of blast-furnace gas; consumes 2200 to 2400 German heat units per b.hp-hr., at full load; application of tandem gas engines for driving dynamos.

GAS PRODUCERS

Ash-Fusion. Ash Fusion Gas Producer, M. A. Fichet. Am. Gas Jl., vol. 116, no. 24, June 17, 1922, pp. 550–552, 2 figs. Producer resembling small blast furnace in which complete combustion is attained by burning coal to fusion of ash. From Journal des Usines à Gaz., 1922, pp. 1–7.

Brick Manufacture. The Use of Producers and Their Gas in Burning Brick (Ueber die Verwendung von Generatoren und ihrer Gase zum Brennen von Ziegeln), Hubert Hermanns. Wärme, vol. 45, nos. 22 and 23, June 2 and 9, 1922, pp. 271–273 and 286–289, 17 figs. June 2: Compares gas- and direct-firing and describes various types of producers comparing their heat balance. June 9: Annular furnaces fired with producer gas; drying of wet lignite gas.

Electric. Gasification of Fuels by Means of the Electric Current (Vergasung von Brennstoffen mit Hilfe des elektrischen Stromes), Gwosdz. Wärme, vol. 45, no. 20, May 19, 1922, pp. 247–250, 1 fig. Application of electric curent to gas producers; describes Stassano, Girod, Holengren, and other types of apparatus.

GASES

Hydraulic Compression. Production of Pure Gases by the Principle of Hydraulic Compression (Gewinnung reiner Gase unter Anwendung des hydraulischen Kompressionprinzips), C. Heirich. Zeit. für komprimierte u. flüssige Gase, vol. 22, nos. 1, 2 and 3, 1922, pp. 3–7, 21–22 and 43–44 1 fig. Principles and operation of hydrocompressor; gives cost data of a plant; use of hydraulic compressors in Linde liquefaction and rectification process for production of liquid or gaseous oxygen.

GASOLINE METERS

Grandberg. An Accurate Gasoline Meter, A. J. Dickie. West. Machy. World, vol. 13, no. 6, June 1922, pp. 189–191, 204, 8 figs. Description of measuring device invented by Grandberg and which requires tooling for manufacture on quantitative production basis.

GEAR CUTTING

Bevel. Cutting Bevel Gears, Franklin D. Jones. Machy. (N. Y.), vol. 28, no. 12, Aug. 1922, pp. 968–971, 7 figs. Principal adjustments required in setting up Gleason bevel-gear generators and time required for cutting gears of different sizes and pitches.

High-Speed. Producing Gears in Quantity at High Speed, J. H. Rodgers. Can. Machy., vol. 28, no. 1, July 6, 1922, pp. 33–35, 4 figs. Modern gear cutters very efficient; multiple fixtures reduce non-productive time; automatic operation practically eliminates possiblity of error; special method for bevel gears.

GEARS

Gear-Tooth Comparator. A New Instrument for Checking Gear Tooth Profiles and Spacing. Automotive Industries, vol. 47, no. 4, July 27, 1922, p. 171, 3 figs. Describes odontometer for comparing uniformity or determining interchangeability of gears. Applicable to gears of any pressure angle; can be applied while gear is still in machine.

GIRDERS

Calculation. Calculation of Girders on Two Supports Partly Fixed (Calcul général des pièces à deux appuis à encastrement partiel), Louis Gellusseau. Génie Civil, vol. 80, nos. 14, 15, 16, 17, 18, 24 and 25, Apr. 8, 15, 22, 29, May 6, June 17 and 24, 1922, pp. 315–318, 335–339, 359–361, 375–378, 401–403, 546–548, and 564–567, 32 figs. Discusses reinforced-

concrete construction; detailed definition of "encastrement;" develops formulas and makes calculations for string boards, rectangular frames, circular and parabolic arches, girders with constant and variable cross-sections, etc.

GLASS MANUFACTURE

Factories. The Modern Glass Factory, W. S. Mayers. Glass Industry, vol. 3, no. 7, July 1922, pp. 129–134, 2 figs. Location, with consideration to power and water; buildings; auxiliary equipment; air ducts; railroad sidings, and various other features.

Movement in Pots and Tanks. Movement of Molten Glass in Pot Furnaces and Tanks, Henry W. Hess. Glass Worker, vol. 41, no. 40, July 1, 1922, p. 11. Changes of temperature affect movement of refined glass. Careful regulation of furnace conditions will eliminate most troubles. Production of cords and waves in pots.

Optical Glass. Manufacture of Optical Glass (Fabrication des Verres d'Optique), Paul Nicolardot. Nature, no. 2518, July 8, 1922, pp. 17–23, 9 figs. Prime materials used; refractories and furnaces; molding, annealing, coloring, etc.

The Manufacture of Optical Glass (Ueber die Herstellung von optischem Glas). Sprechsaal, vol. 55, nos. 17, 18, 19 and 20, Apr. 27, May 4, 11 and 18, 1922, pp. 195–198, 209–211, 221–222, and 233–235, 13 figs. Apr. 27: Methods developed in England during war. May 4: Coloring and testing; optical constants; scientific side of glass manufacture. May 11: Relation between composition of glass and refractory index. May 18: Relation between composition and durability; molecular composition and solubility.

Presses, Automatic. Balanced Toggle Aids in Getting Proper Degree of Pressure. Glass Worker, vol. 41, no. 43, July 22, 1922, pp. 11 and 29–30, 5 figs. Mechanism for pressing glassware by balanced toggle produces proper weight pressure at all times.

GRINDING

Bearings. Grinding in the Automotive Industry. Machy. (N. Y.), vol. 28, no. 12, Aug. 1922, pp. 946–951, 11 figs. Methods of grinding steel balls and ball-bearing races; grinding roller-bearing cups, cones and rollers.

H

HANGARS

Cable-Suspended Roof. Cable-Suspended Roofs for Hangars, Workshops, Docks, Etc. (Toitures supportées par des fermes de suspension isostatiques en cables pour hangars, ateliers, docks, etc.), G. Leinekugel le Cocq. Bul. de la Société d'Encouragement pour l'Industrie Nationale, vol. 134, no. 5, May 1922, pp. 396–417, 15 figs. Describes construction of Cherbourg and other hangars with very wide span in which roof is suspended from cables at either end.

HARDNESS

Testing. Hardness Testing Methods (Sur les Méthodes d'essai de dureté des corps), Georges Moreau. Révue Générale de l'Électricité, vol. 12, no. 3, July 22, 1922, pp. 106–111, 3 figs. Describes new method of testing materials, being improvement on Brinell method, i.e., dynamic hardness which is defined as relation between pressure exerted by ball during penetration on surface of impression.

The Testing of Metals for Hardness, S. P. Rockwell. Am. Soc. for Steel Treating Trans., vol. 2, no. 11, Aug. 1922, pp. 1013–1033, 27 figs. Results of tests made on standard Brinell, scleroscope and Rockwell hardness-testing machines.

HEAT STORAGE

Apparatus. Heat Storage Apparatus, C. Boileau. Elec. Times, vol. 62, no. 1603, July 6, 1922, pp. 7–9. Raising of central-station load factors by electric heat storage. From L'Électricien.

HEAT TRANSMISSION

Non-Conducting Materials. The Transmission of Heat Through and the Efficiency of Non-Conducting Materials, Masao Kinoshita. Domestic Eng. (English), vol. 42, no. 42, June 1922, pp. 116–120, 5 figs. Mathematical consideration (1) in which distribution of temperature in system of bodies considered remains unchanged; and (2) in which temperature distribution changes from time to time.

Refractory Materials. The Thermal Conductivity of Refractory Materials at High Temperatures, A. T. Green. Gas World, vol. 77, no. 1908, July 1, 1922, pp. 13–18, 2 figs. Review of previous work; Fourier's linear-diffusion equation; measurement of rate of rise of temperature for isothermal plane at known distance from hot face; texture; porosity; results. Paper read before Instn. Gas Engrs.

HYDRAULIC TURBINES

Queenston-Chippawa Plant. 55,000-Hp. Turbines for the Queenston Power Station, Ontario. Engineering, vol. 114, no. 2950, July 14, 1922, pp. 31–35, 19 figs. Description of turbines of Queenston-Chippawa development with illustration.

HYDROELECTRIC DEVELOPMENTS

Canadian Progress. Hydro-Electric Progress in Canada. Universal Engr., vol. 35, no. 6, June 1922, pp. 24–27. Brief review of development work in individual provinces and of progress in investigation and plans.

Germany. South German Electric Economics (Die Süddeutsche Elektrizitätswirtschaft), H. Pütz. Elektrotechnische Zeit., vol. 43, no. 27, July 17, 1922, pp. 901–904, 1 fig. Water-power resources of Bavaria, Baden and Württemberg; the question of equal distribution; consumption of energy; 110-kv. transmission line.

India. The Hydro-Electric Survey of India, J. W. Meares. Beama, vol. 10. no. 6, June 1922, pp. 409–411. 350,000 hp. developed or under construction; $1^1/_2$ million hp. investigated by Survey; $1^1/_2$ million in known sites not yet investigated; probably 4 to 10 million more.

The Power Factor—India's Natural Resources. Indian Industries & Power, vol. 19, no. 9, May 1922, pp. 302–307, 3 figs. General consideration of value of power development to Indian industry. Table of investigated prospects.

Queenston-Chippawa, Canada. Queenston-Chippawa Developments of the Hydro-Electric Power Commission of Ontario, F. A. Gaby. Am. Int. Elec. Engrs. Jl., vol. 41, no. 7, July 1922, pp. 508–526, 29 figs. General description of entire development on Canadian side of Niagara River which will have ultimate capacity of approximately 650,000 hp.

Tugalo River. Water Power Development on the Tugalo River. Eng. World, vol. 21, no. 1, July 1922, pp. 7–8, 5 figs. Georgia Ry. & Power Co. 50,000-Kw. development costing $1,600,000 to be finished next year.

HYDROELECTRIC PLANTS

France. Hydroelectric Plant at Mouthier (L'usine génératrice hydroélectrique de la Loue, à Mouthier), J. Reyval. Révue Générale de l'Électricité, vol. 11, no. 19, May 13, 1922, pp. 691–714, 21 figs. Describes generating station at Mouthier on the Loue; total power 16,000 hp.; generating equipment; overhead lines; transformers; stations, etc.

Hydroelectric Plant of the Paul Girod Steel Works at Ugines, Savoie [Les Usines hydro-électriques de la Compagnie des Forges et Aciéries électriques Paul Girod a Ugines (Savoie)], V. Sylvestre. Houille Blanche, vol. 21, no. 65–66, May-June 1922, pp. 73–83, 10 figs. Describes civil-engineering work in connection with construction of dams and reservoirs; pressure piping; Pelton wheels; etc.

Germany. Concrete and Reinforced-Concrete Works at the Isar (Beton- und Eisenbetonarbeiten an der Mittleren Isar), Hans Stanglmayr. Bauingenieur, vol. 3, no. 11, June 15, 1922, pp. 334–342, 9 figs. Reviews number of hydroelectric power works on this river in vicinity of Munich, and gives details of construction work.

New Hydroelectric Plants in Bavaria and Thuringia (Neuere Wasserkraftanlagen in Bayern und Thüringen), Schwenk. Bauingenieur, vol. 3, nos. 8, 9, 10 and 11, Apr. 30, May 15, 31 and June 15, 1922, pp. 230–234, 267–273, 300–307 and 330–334, 40 figs. Apr. 30: Civil engineering features of Wisenttal power plant and electric equipment, including Francis double-spiral turbines by Escher, Wyss & Co., and d.c. generators by Siemens-Schuckert. May 15: Describes power plant at Ziegenrück, on river Saale, its constructional features and equipment. May 31: Describes power plant at Hausen; hydraulic features, turbine equipment, etc. June 15: Describes power plant No. 2 at Munich, South, and its equipment, including two units of two coupled Francis turbines each, having head of 4.4 m., 1760 hp. at 125 r.p.m., and 80 per cent efficiency.

Italy. Hydroelectric Plant of the Barbellino (L'impianto idroelettrico del Barbellino), F. Zanon. Industria, vol. 36, no. 11, June 15, 1922, pp. 201–208, 9 figs. Hydraulic construction work; dams and reservoirs of the lakes of Barbellino, Malgina and Valmorta; power piping; list of central stations drawing their water power from these lakes.

Sweden. Haugesund Electric Power Station (Haugesundhalvöens og Karmöys elektrisitetsforsyningsanlaeg), O. Aas-Jörgensen. Teknisk Ukeblad, vol. 69, no. 27, July 7, 1922, pp. 252–255, 9 figs. Construction work and equipment of this high-tension station with 60,000 volts capacity.

Switzerland. An Extra-High Head Hydro-Electric Plant. Engineer, vol. 134, no. 3474, July 28, 1922, pp. 88–90, 9 figs. Description of Fully plant in Switzerland, operating under head of 1650.7 m., or 5416 ft.

I

ICE MANUFACTURE

Clear Ice. Making of Clear Ice, John E. Starr. Refrig. World, vol. 57, no. 7, July 1922, pp. 11–12 and 14. Increase to ice-making capacity and cold-storage space obtained by remodelling and modernizing plant and equipment.

Development. Development in the Manufacture of Ice, Harry T. Whyte. Nat. Engr., vol. 26, no. 7, July 1922, pp. 290–293, 13 figs. Review of progress of industry; advantages and disadvantages of present types; economics of plant operation.

ICE PLANTS

Refrigerator Cars, for. Car Icing Station for the Belt Railway of Chicago. Eng. News-Rec., vol. 89, no. 6, Aug. 10, 1922, pp. 240–242, 4 figs. Refrigerator cars at transfer yard supplied with cake or crushed ice; conveyors, carts and portable chutes.

IGNITION

Angle of Cylinder Axes. Angle of Cylinder Axes for Uniform Ignition (Gabelwinkel für gleichmässige Zündfolge bei mehrreihigen Verkehrsmotoren), H. Schrön. Motorwagen, vol. 25, nos. 16 and 17, June 10 and 20, 1922, pp. 307–312 and 329–333, 107 figs. Describes angle of cylinder axes in connection with crankshaft arrangements for multiple-cylinder motors. Concludes that construction with cylinders opposite each other leaves free choice of angle but complicates crankshaft; normal construction simplifies crankshaft.

High-Tension Spark. High-Tension Spark-Ignition in Internal-Combustion Engines, J. D. Morgan. Instn. Mech. Engrs. Proc., no. 2, 1922, pp. 303–315, 6 figs. What is expected of spark generators and discussion of spark and conditions affecting its production.

IMPACT TESTING

Alloy Steels. Significance of the Impact Test, F. C. Langenberg and N. Richardson. Forging & Heat Treating, vol. 8, no. 7, July 1922, pp. 309–312. Typical test data on certain alloy steels and ordnance steels are recorded, illustrating author's conclusions and furnishing opportunity for comparison of static and dynamic tests. Paper from Symposium before Am. Soc. for Testing Matls.

INDUSTRIAL MANAGEMENT

Ford's Four Production Principles. Ford's Four Production Principles, Samuel Crowther. Factory, vol. 29, no. 1, July 1922, pp. 15–17. Never letting well enough alone; always apportioning responsibility definitely; holding foremen not for costs but for production; treating interest charges as decreased profit.

Forge Shops, Records. Miscellaneous Records, Statistics and Suggestions for Drop Forgers, Geo. H. Koskey. Forging & Heat Treating, vol. 8, no. 7, July 1922, pp. 317–320. Suggesting sliding scale upward, where production depends on human elements; in this case firm would make profit on more pieces, reduce cost and benefit worker.

Malleable Shop System. System Rules Malleable Shop, H. E. Diller. Foundry, vol. 50, no. 13, July 1, 1922, pp. 537–541, 8 figs. Records of progress of work in large foundry are kept on simplified forms; four men handle routine for more than 200 molders; how work is scheduled.

Stabilizing Profits by Charts. Charting as an Aid in Stabilizing Profits, Percy A. Bivins. Indus. Management, vol. 63, nos. 5 and 6, and vol. 64, no. 1, May, June and July 1922, pp. 257–265, 355–361 and 33–42, 29 figs. Enabling executives to apply graphic methods to problem of profit stabilization.

[See also TIME STUDY.]

INSPECTION

See OPTICAL INSTRUMENTS.

INSTRUMENTS

Scientific, Mechanical Design. The Mechanical Design of Scientific Instruments. Engineering, vol. 113, nos. 2945, 2946, 2947 and 2948, June 9, 16, 23 and 30, 1922, pp. 729–730, 763–764, 794, and 828–829, 24 figs. Consideration in design of qualitative and quantitative instruments used in many branches of physical, engineering and chemical sciences. Abstract of three Cantor Lectures delivered before Royal Soc. of Arts.

INTERNAL-COMBUSTION ENGINES

Marine, Still System. Still System of Internal Combustion Engine for Marine Purposes, F. L. Martineau. Inst. Mar. Engrs. Trans., vol. 34, Apr. 1922, pp. 37–47, and (discussion) 47–58, 2 figs. Discussion of Still system; any internal-combustion engine can operate on it by certain modifications and improve its results 20 per cent.

Maximum Pressures. Comparing Maximum Pressures in Internal Combustion Engines, Stanwood W. Sparrow and Stephen M. Lee. Nat. Advisory Committee for Aeronautics Tech. Notes no. 101, June 1922, 4 pp., 3 figs. Thin metal diaphragms form satisfactory means; diaphragm is clamped between two washers in spark-plug shell and its thickness is chosen such that when subjected to explosion pressure exposed portion will be sheared from rim in short time.

Price Horizontal Engine. The Price Horizontal Engine. Power Plant Eng., vol. 26, no. 14, July 15, 1922, pp. 707–708, 4 figs. Combustion at constant volume, solid injection of fuel in two sprays.

Sulzer Two-Cycle. Four Cylinder Two-Cycle Sulzer Engine. Mar. Eng. vol. 27, no. 7, July 1922, pp. 443–444, 1 fig. Designed to develop 2,000 b.hp. at 100 r.p.m.; turbo scavenging pumps used.

Sulzer 2-Cycle Marine Engine, L. J. LeMesurier. Inst. Mar. Engrs. Trans., vol. 33, Mar. 1922, pp. 723–776 and (discussion) 776–790, 45 figs. Discussion of relative merits of 4- and 2-cycle internal-combustion engines and reasons for adoption of 2-cycle for larger powers by Sulzers.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; IGNITION; OIL ENGINES; SEMI-DIESEL ENGINES.]

IRON

Puddled. Make Puddled Iron Mechanically, E. C. Kreutzberg. Iron Trade Rev., vol. 71, no. 6, Aug. 10, 1922, pp. 365–366, 9 figs. Description of puddler developed at Eastern plant producing 1500-lb. puddle balls at rate of one per hr.

IRON AND STEEL

Fiber in. Fiber in Iron and Steel, F. F. McIntosh. Am. Soc. for Steel Treating, Trans., vol. 2, no. 10, July 1922, pp. 856–863 and (discussion) 864–868, 9 figs. Importance of fiber in performance of iron or steel and factors which govern formation and character.

IRON CASTINGS

Manufacture Direct from Ore. Making High-Grade Castings Direct from the Ore, F. H. Bell. Can. Foundryman, vol. 13, no. 7, July 1922, pp. 17–18, 2 figs. Ore melted in ordinary blast furnace is kept in vacuum thermos container until chemical analysis is taken, after which it is mixed with cupola iron.

Rolls. Casting Rolls (Walzenguss), Carl Irresberger. Giesserei Zeitung, vol. 19, nos. 23, 24, 25 and 26, June 6, 13, 20 and 27, 1922, pp. 342–345, 354–358, 371–374 and 381–386, 55 figs. Processes of casting steel rolls; tempered and untempered cast-iron rolls; molds; annealing furnaces; hardening and depth of penetration; hollow rolls.

Typewriter Frames. Making Typewriter Frames in a Belgium Foundry, Joseph Leonard. Can. Foundryman, vol. 13, no. 6, June 1922, pp. 32–33, 8 figs. Method of molding and casting. Comparatively simple rigging designed to produce 35 to 40 frames per day.

J

JAPANNING

Methods. Japanning, S. R. Gerber. Metal Industry (N. Y.), vol. 20, nos. 6 and 7, June and July 1922, pp. 225–227 and 161–163, 5 figs. Description of methods by which rule-of-thumb operations of an old art were changed to standard operations.

K

KEROSENE

Vegetable and Animal Oils as Sources. Catalytic Transformation of Vegetable and Animal Oils Into Kerosene (Transformation catalytique des huiles végétales et animales en pétrole), Alphonse Mailhe. Annales de Chimie, vol. 17, May-June 1922, pp. 304–332. Concludes that it is easy to reduce hydrocarbons from animal and vegetable oils, and that resulting hydrocarbons are in nature of mixed kerosenes very much like Borneo kerosene which has similar composition.

L

LABOR

Craftsmen Councils. Brief History of Craftsmen Movement in Cleveland. Universal Engr., vol. 36, no. 2, Aug. 1922, pp. 42, 44 and 46, 1 fig. Organization of craftsmen councils by groups of masons engaged in same line of industry.

India. Inefficiency Offsets India's Cheap Labor, James Allen DeForce. Iron Trade Rev., vol. 71, no. 6, Aug. 10. 1922, pp. 368–369. General data with some information on labor regulation.

LABORATORIES

Electrotechnical. Technical Laboratories of the Postal Telegraph Office (Le laboratoire technique des postes et télégraphes), Jacques Boyer. Nature, no. 2512, May 27, 1922, pp. 325–330, 8 figs. Describes Paris official laboratory in which telegraph, telephone and other instruments of the service are tested.

Testing, Electric. A 500,000-Volt Testing Laboratory (Un laboratoire d'essais à 500,000 volts), H. de Raemy. Révue Générale de l'Électricité, vol. 11, no. 23, June 10, 1922, pp. 861–864, 6 figs. Describes new laboratory of Ateliers de Constructions électriques de Delle, at Villeurbanne, which is especially designed for testing of high-tension apparatus for transmission lines.

LADLES

Stopper. Development in Design of Casting Ladle Bungs. Metal Industry (Lond.), vol. 20, no. 26, June 30, 1922, pp. 621–622, 6 figs. Discussion of design which should make connection between bung rod and bung absolutely certain and easy to effect. From Stahl u. Eisen.

LIGHTING

Glareless. Light Without Glare, Ward Harrison. Am. Inst. Elec. Engrs. Jl., vol. 41, no. 8, Aug. 1922, pp. 609–615, 8 figs. Discussion of features determining satisfactory illumination without glare. Includes tables from Illuminating Eng. Soc. Code of Indus. Lighting in which for first time light sources are modified.

Industrial. Good Lighting an Essential in the Efficient Conduct of Business, J. H. O'Hara. Elec. News, vol. 31, no. 13, July 1, 1922, pp. 36–39. Expenditure of one-half of one per cent of pay roll increases output five per cent. Saving equal to ten times expense. Practical example. Paper read before C.E.A. convention.

Rational Lighting (Considerations sur l'éclairage rationnel), R. Wolff. Électricien, vol. 37, no. 1290. Dec. 15, 1921 and vol. 38, nos. 1297, 1298 and 1299, Apr. 1, 15 and May 1, 1922, pp. 553–561, 145–151, 174–177 and 193–197, 38 figs. Dec. 15: Photometry; intensity; measurement of light. Apr. 1: Lighting of business establishments; direct and indirect lighting; reflective power of various paints; etc. Apr. 15: Describes reflectors of various types and their curves of luminosity. May 1: Extent to which light is used in various systems of direct, indirect, etc., lighting.

The Problems of Electric Lighting (Die Aufgaben der elektrischen Beleuchtung), H. Lux. Elektrotechnische Zeit., special no., May 28, 1922, pp. 32–40, 19 figs. The various types of direct and indirect lighting and description of apparatus.

Lecture and Drafting Rooms. Illumination of Lecture and Drawing Halls (Die Beleuchtung von Hör- und Zeichensälen), W. Wedding. Zeit. für Beleuchtungswesen, vol. 28, no. 11–12, June 15–30, 1922, pp. 73–76, 15 figs. Results of examination of number of halls. Finds that most of the arc lights have been replaced by half-watt lamps. Tabular statement of illumination data of halls inspected.

Office Buildings. Indirect Lighting in City Office Building, G. F. Evans & J. W. Morrison. Elec. World, vol. 80, no. 2, July 8, 1922, pp. 61–62, 6 figs. Dixie terminal building in Cincinnati uses system with 8 to 15 foot-candles; arcade illumination eliminates hanging fixtures; aids to maintenance included in design.

Safety. Illumination and the Worker, G. Bertram Regar. Safety, vol. 9, no. 7, July 1922, pp. 156–160, 4 figs. Value of correct use in making for safe conditions in industry.

LIGNITE

Carbonization. Modern Methods of Treating Lignite and Its Derivatives (Procédés modernes pour le traitement du lignite et de ses derives). Chaleur et Industrie, vol. 3, no. 25, May 1922, pp. 1274–1276, 2 figs. Discusses carbonization; Fischer rotary furnace.

Degasification. Comparative Experiments on Degasification of Lignite on a Technical and Laboratory Scale (Vergleichende Versuche über Entgasung von Braunkohle im technischen und Laboratoriums-Massstabe), K. Bunte and Fritz Schwarzkopf. Gas- u. Wasserfach, vol. 65, nos. 21, 22 and 23, May 27, June 3 and 10, 1922, pp. 322–325, 340–343 and 355–357, 15 figs. Experiments carried out with dirty Luckenau lignite for purpose of obtaining better results as to behavior of material than can be obtained from elementary analysis and coking sampling. Methods used were those of Groppel, Strache, and muffle furnace.

LIME

Plants. New Lime Plant is Last Word in Modern Efficiency, William B. Eastwood. Cement, Mill & Quarry, vol. 21, no. 2, July 20, 1922, pp. 35–41 and 44, 14 figs. Mining, crushing, screening, calcining, hydrating and shipping are continuous without waste or climatic interruption.

LIQUIDS

Inflammable, Storage of. Storing Inflammable Liquids (Lagerung feuergefährlicher Flüssigkeiten). Zeit. des Bayerischen Revisions-Vereins, vol. 26, no. 12, June 30, 1922, pp. 100–102, 1 fig. Bavarian safety regulations for storage of petroleum, benzene, gasoline, etc., especially use of protective gas.

LOCOMOTIVE BOILERS

Circulation Effect on Efficiency. Effect of Circulation on Locomotive Boiler Efficiency, F. G. Lister. Steam, vol. 30, no. 1, July 1922, pp. 7–10. Recent attempts to create more rapid and unrestricted circulation thereby attaining more nearly uniform temperature throughout and reducing equal expansion and contraction of all parts. Paper read before Int. Ry. Fuel Assn.

LOCOMOTIVES

Combat. The Design of Combat Locomotives, R. S. Twogood. Jl. Pacific Ry. Club Proc., vol. 6, no. 3, June 1922, pp. 9–12. Notes on design deduced from experiences with those sent to France during recent war.

Design and Construction. Report on Locomotive Construction. Ry. Age (Daily), vol. 72, no. 24d, June 21, 1922, pp. 1631–1639. Various developments of year and résumé of 11 reports including recommendations (A.R.A. Mech. Div. Proc.).

Drifting Valves. When a Locomotive Drifts. Ry. Jl., vol. 28, no. 8, Aug. 1922, pp. 21–22, 3 figs., Description of Ripken automatic drifting valve.

Electric. See ELECTRIC LOCOMOTIVES.

Failure Causes and Remedies. Why Engines Fail, Frank C. Packard. Central Ry. Club Proc., vol. 30, no. 3, May 1922, pp. 1187–1198 and (discussion) 1198–1217. Analysis of failure and causes; losses caused thereby and argument for placing of full responsibility.

Fuel Consumption. Effect of Tonnage and Speed on Fuel Consumption, J. E. Davenport. Ry. Age, vol. 73, no. 2, July 8, 1922, pp. 71–75, 8 figs. Ton miles per hr. affects fuel rate; economical tonnage for various speeds, effect of grade and car weight. (Abstract.) Paper read before Int. Ry. Fuel Assn.

Increasing Mileage of. Increasing Locomotive Mileage—A Chemical Problem First, W. H. Hobbs. Ry. Rev., vol. 71, no. 1, July 1, 1922, pp. 11–12. Why better boiler feedwater is essential to increase in productive time of locomotives.

Mikado. New and Interesting Mikado Type Locomotive Built at the Lima Locomotive Works for the Michigan Central. Ry. & Locomotive Eng., vol. 35, no. 8, Aug. 1922, pp. 199–201, 4 figs. Specifications: Total length, 82 ft.; cylinder 28 in. by 30 in.; weight exclusive of tender, 334,000 lb.; weight of tender, 199,700 lb. with capacity of 16 tons fuel and 10,000 gal. water; driving-wheel diam., 63 in.

Mountain Type. A Mountain Type Locomotive for High Capacity. Ry. Mech. Engr., vol. 96, no. 7, July 1922, pp. 381–385, 11 figs. New Union Pacific locomotive is lightest per unit of power of any 4-8-2 yet built, weighing 345,000 lb. and having maximum tractive effort of 54,800 lb. See also Ry. Rev., vol. 70, no. 23, June 10, 1922, pp. 815–825, 16 figs. partly on supp. plate.

Oil-Burning. Oil Fuel for Locomotives on the Taltal Railway of Chile, W. H. Revill. Ry. Gaz., vol. 36, no. 26, June 30, 1922, pp. 1030–1034, 6 figs. Comparison of oil and coal as fuel; economies which have been effected by use of oil; design of oil-fuel apparatus burners.

Operation. Work of the Commission for the Utilization of Fuel—6th Report (Travaux de la Commission d'Utilisation du Combustible—Sixième Rapport). Bul. de la Société d'Encouragement pour l'Industrie Nationale, vol. 134, no. 6, June 1922, pp. 565–599. Report of First Sub-Committee. Efficiency of locomotives; steam consumption and distribution; feedwater preheating; operation of locomotives.

Steam-Turbine. The Ljungström Turbine Locomotive (Ljungströms turbinlokomotiv), Fredrik Ljungström. Teknisk Tidskrift, vol. 52, nos. 21, 22, 23, and 25, May 27, June 3, 10 and 23, 1922, pp. 331–333, 348–351, 363–367 and 396–400, 31 figs. Experimental work, and construction and operation of locomotives driven by steam turbines. Particulars of saving resulting.

Turbo-Condensing. Turbo-Condensing Locomotive Development in Europe. Ry. Rev., vol. 71, no. 7, Aug. 12, 1922, pp. 201–207, 9 figs. Details of Ljungström turbine-condensing locomotive placed in service on Swedish State Railways.

LUBRICATING OILS

Analysis. Technical Examination of Lubricating Oil and Grease, F. W. Watson and H. D. Bell. Chem., Met. & Min. Soc. of So. Africa Jl., vol. 22, no. 11, pp. 211–219. Analytical methods and data. Results of tests.

Coolers for. Tubular Oil Cooler. Engineering, vol. 114, no. 2951, July 21, 1922, p. 89, 6 figs. Describes marine cooler having 250 sq. ft. cooling space, and which will deal with 1½ million B.t.u. per hr. Constructed by Serck Radiators, Ltd.

LUBRICATION

Mechanism of. The Mechanism of Lubrication, Robt. E. Wilson and D. P. Barnard, 4th. Soc. Automotive Engrs. Jl., vol. 11, no. 1, July 1922, pp. 49–60, 11 figs. Presenting best available data to afford basis for predicting effect of different variables under any specified conditions.

Oil Drops. What Determines the Size of the Oil Drop, W. F. Osborne. Power, vol. 56, no. 7, Aug. 15, 1922, pp. 251–252. Discussion of conditions affecting size of oil drops going to engine cylinder.

M

MACHINE TOOLS

Gear Drive. Methods of Machine Tool Design, A. L. De Leeuw. Am. Mach., vol. 57, no. 6, Aug. 10, 1922, pp. 223–227, 12 figs. Comparative merits of cone and tumbler quick gear-change device.

MACHINING

Deformation During. Avoiding Deformation During Machining, A. Whitehead. Engineer, vol. 134, no. 3474, July 28, 1922, pp. 98–99, 3 figs. Discusses as example, chucking of a ball race, machining small piston, and holding small armature.

MAGNESIUM ALLOYS

Engineering Uses. Magnesium Alloys in Engineering. Practical Engr., vol. 65, no. 1844, June 29, 1922, pp. 404–405, 2 figs. Electron (containing 80 per cent magnesium) for automobile pistons; general physical characteristics and precautions in molding.

MALLEABLE IRON

Drilling Data. Malleable-Iron Drilling Data, H. A. Schwartz and W. W. Flagle. Soc. Automotive Engrs. Jl., vol. 11, no. 1, July 1922, pp. 81–87, 12 figs. Drill tests of five factors that influence machining properties of malleable iron.

MARINE STEAM TURBINES

Low-Pressure Capacity. Capacities of Low-Pressure Marine Steam Turbines, W. G. P. Mech. World, vol. 71, no. 1852, June 30, 1922, pp. 466–467, 2 figs. Low- and high-steam velocity considerations in respect to turbine design and weight; mathematical development.

MATERIALS

Testing. Testing Materials for Shipbuilding, Leon Guillet. Engineering, vol. 114, no. 2950, July 14, 1922, pp. 57–58, 6 figs. Methods of testing. Tensile, falling weight, ball hardness, punching, wearing, alternating, and physical tests, and macrographic investigations.

MEASURING INSTRUMENTS

End Measurement. Accurate End Measurement on Measuring Machines Using a Screw, H. Baker. Engineer, vol. 134, no. 3474, July 28, 1922, pp. 81–83, 6 figs. Experiments relating to attempts to measure correctly to one ten-thousandth of a millimeter. Description of machine used and methods.

Hollow Membrane. Measuring and Regulating by Means of a Hollow Membrane (Messen und Regeln mit Hilfe der Hohlmembran), E. Stach. Glückauf, vol. 58, no. 26, July 1, 1922, pp. 807–813, 10 figs. Requirements of measuring and recording instruments as to construction and sensitiveness; shows that hollow metal membrane recorder gives better results than wet measuring instruments.

METAL SPRAYING

Metals for. Metals and Alloys Suitable for Spraying (Für Spritzguss geeignete Metalle und Legierungen), F. Reinboth. Metall-Technik, vol. 48, no. 24, June 8, 1922, pp. 266-267. Gives composition of various alloys and rules for their choice for a given purpose which requires given physical or electrical properties.

Schoop Process. The Schoop Metal Spraying Process With Special Reference to Its Application in Shipbuilding (Das Schoopsche Metallspritzverfahren), M. U. Schoop. Schiffbau, vol. 23, no. 38, June 21, 1922, pp. 1106-1107, 1 fig. Describes various uses of metallizing pistol for covering chains, anchors, etc., with zinc, ship bottoms and propellers with copper, etc.

METALS

Electroanalysis of Alloys and. Electroanalysis of Metals and Alloys, Kling and Lassieur. Chem. Trade Jl. and Chem. Engr., vol. 71, no. 1835, July 21, 1922, pp. 73-74. Description of new rapid method of electrolytic analysis applicable to wide range of metals. Translated from Annals de Chimie Analytique, June 15, 1922.

Hardening. On the Theory of the Hardening of Metals, Kotaro Honda. Science Reports Tôhoku Imperial Univ., 1st series, vol. 11, no. 1, Apr. 1922, pp. 19-28. Martensite being homogeneous solid solution, is hard principally because of nature of atomic forces; consideration of hardness due to crystalline structure of metals.

Spinning. Metal Spinning and Spinning Tools, Edward Heller. Machy. (N. Y.), vol. 28, no. 12, Aug. 1922, pp. 972-976, 9 figs. Description of machinery and methods for various types of spinning.

MILLING MACHINES

Aligning and Inspecting. Aligning and Inspecting Milling Machines. Machy. (Lond.), vol. 20, no. 511, July 13, 1922, pp. 441-444, 6 figs. Methods employed by manufacturers of Cleveland milling machine.

MOLDING MACHINES

Types. Molding Machines (La staffatura a scosse ed alcuni tipi di staffatrici), P. A. Sordelli. Industria, vol. 36, no. 11, June 15, 1922, pp. 211-214, 9 figs. Describes various types of molding machines with pneumatic stripping arrangement, including that of Britannia Foundry, Coventry, and that of Leber & Bröse, and their operation.

MONEL METAL

Tubular Uses. Monel Metal's Merits in Tubular Uses, J. L. Sussman. Raw Material, vol. 5, no. 6, July 1922, pp. 208-210, 6 figs. Manufacture in tube form is step toward solving problem of chemically resistant, non-fragile material.

MORTARS

Lime. Hardening of Hydraulic Binders—Quality and Acceptance of Lime (Le durissement des liants hydrauliques. Qualités et réception des chaux), E. Camerman. Annales de l'Association des Ingénieurs Sortis des Écoles Spéciales de Gand, vol. 12, no. 1, 1922, pp. 1-15, 1 fig. Discusses in detail question of colloidal solutions; silicate and its part in hardening of hydraulic binders; hydraulic lime; tensile strength; specifications.

MOTOR BUSES

Design and Operation. Principles of Motorbus Design and Operation, G. A. Green. Soc. Automotive Engrs. Jl., vol. 11, no. 1, July 1922, pp. 13-26, 26 figs. Safety, comfort and convenience, minimum operating cost and subdivisions of each commented on. Trucks or automobiles cannot render as good service as buses.

Principles of Motor Bus Design and Operation, David Beecroft. Commercial Vehicle, vol. 26, no. 11, July 1, 1922, pp. 12-14, 3 figs. Principles that apply to big Fifth Avenue buses apply also to all buses, everywhere; why design is big factor in successful bus operation. Review of paper presented by Col. Green at semi-annual mtg. of Society of Automotive Engrs.

Developments. Characteristics of Present-Day Buses, R. E. Plimpton. Bus Transportation, vol. 1, no. 7, July 1922, pp. 375-378, 3 figs. Requirements for city, inter-city, and country service considered; comfort and convenience factors found in modern bodies; devices for fare collection now being installed. (Abstract.) Paper read before Soc. Automotive Engrs.

New York State. Turnpikes Turn to Bus Routes in Empire State. Bus Transportation, vol. 1, no. 7, July 1922, pp. 383-389, 2 figs. Maps and tables of statistics and résumé of bus routes and facilities of New York State.

MOTOR TRUCKS

Steam. A Steam Six-Wheeler. Motor Transport, vol. 34, no. 904, June 26, 1922, p. 781, 3 figs. Two-wheeled conversion attachment to Ransomes steam wagon which is said to afford enormous carrying capacity.

A Milestone in Steam Design. Motor Transport, vol. 34, no. 904, June 26, 1922, pp. 768-771, 8 figs. New 7-ton Yorkshire, employing steam power in conjunction with many of best features of gasoline-car practice.

Tipping Gears. Tipping Gears for Motor Lorry Bodies, W. Erskine Dommett. Eng. Rev., vol. 35, no. 12, June 1922, pp. 406-412, 15 figs. Manner in which mechanical and hydraulic types have accomplished speed of operation, angle of tilt, ease when manually actuated, lightness, reliability, and low cost.

N

NITRIC ACID

Manufacture, Saltpeter vs. Synthetic Ammonia. Nitric Acid from Saltpeter or Synthetic Ammonia, Guy B. Taylor. Chem. Age (N. Y.), vol. 30, no. 6, June 1922, pp. 244-246, 1 fig. Cost factors and conditions that will determine raw material of nitric acid manufacture.

NITROGEN

Fixation. The Fixed Nitrogen Research Laboratory. Chem. Age (N. Y.), vol. 30, no. 6, June 1922, pp. 266-267, 4 figs. Equipment and facilities of plant at American University, Wash., D. C., and government work carried on there.

Synthetic, Products. Synthetic Nitrogen Products and the Ammonia Obtained as By-Product in Coal Distillation (Les produits azotés synthétiques, et l'ammoniaque obtenus comme sous-produits de distillation de la houille), A. Grebel. Génie Civil, vol. 80, no. 25, June 24, 1922, pp. 567-570. Influence of different phases of recovery and treatment of ammonia on final yield of sulphate.

NON-FERROUS METALS

Gas Absorption and Oxidation. Gas Absorption and Oxidation, B. Woyski and John W. Boeck. Foundry, vol. 50, no. 14, July 15, 1922, pp. 571-573, 2 figs. Defects in non-ferrous metals caused by gas absorption often erroneously attributed to oxidation; defective metal brought back to normal by proper melting practice; oxides of low gravity remain in metal. Paper read before Am. Inst. Min. & Met. Engrs.

NUMBERS

Duodecimal System. Standardization of Numbers (Die Normung des Zahlenmasses), Alfred Sieber. Maschinenbau, vol. 1, no. 5, June 10, 1922, pp. 280-284, 4 figs. Disadvantages of decimal system and advantages of duodecimal system.

O

OIL

Briquetting. Solid Oil With Peat Vehicle, Wm. A Hall. Petroleum Times, vol. 8, no. 184, July 15, 1922, p. 90. Brief description of method of producing solid oil with peat as vehicle.

Protection from Evaporation. Durable Foam Seal Stops Evaporation and Reduces Fire Risk, Paul Truesdell. Nat. Petroleum News, vol. 14, no. 28, July 12, 1922, pp. 43-44, 1 fig. Sealite, compound containing 50 per cent air, cornstarch, glycerine and gelatine and other ingredients, when poured over top of tank of oil, spreads over surface, forming floating seal which prevents evaporation and fire.

OIL ENGINES

Bolinda. Bolinda Oil Engines of New Type. Shipping, vol. 16, no. 1, July 1922, pp. 42-43, 1 fig. New fuel injection device fitted on top of ignition bulb from which fuel is sprayed downward toward piston thereby eliminating fresh-water and compressed-air injection for maintaining constant hot-bulb temperature.

Design. The Oil Engine of Today, Chas. E. Lucke Power, vol. 56, no. 7, Aug. 15, 1922, pp. 241-243, 2 figs. Discussion of recent improvements in general design that have made oil engine thoroughly reliable, including fuel charging and cylinder cooling.

Heavy-Oil. Present State of Heavy-Oil Engines (État Actuel de la Question des Moteurs a Huile Lourde), Marcel Bochet. Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils de France, vol. 75, no. 1-3, Jan.-Mar. 1922, pp. 87-105, 15 figs. partly on supp. plates. Discusses marine engines used in various shipyards; describes semi-Diesel engine and its operation.

Marine. Types of Large Marine Oil Engines, David R. Hutchison. Inst. Mar. Engrs. Trans., vol. 34, Apr. 1922, pp. 1-30 and (discussion) 31-37, 21 figs. Novel features of Scott-Still engine as representing newest types. Operating cycles and fuel economy; cylinder charging and exhausting; combustion of fuel; cooling; framing; valve and maneuvering gear.

Operation. Oil Engine Hints, Bert Bare. Power Plant Eng., vol. 26, no. 14, July 15, 1922, pp. 704-707, 2 figs. Hot ignition; missing; hunting; failure to start; loss of compression; compression card.

OIL FUEL

Ships. Oil Fuel In Ships. Steamship, vol. 34, no. 397, July 1922, pp. 21-24, 6 figs. Many advantages of oil coal and review of some features of oil burning.

Vegetable. Using Vegetable Oils for Fuels (Utilisation des huiles végétales comme combustibles industriels), Maurice Leduc. Chaleur et Industrie, vol. 3, no. 25, May 1922, pp. 1277-1280. Their calorific power; French vegetable oils; unlimited production; use in oil-burning installations.

OFFICE MANAGEMENT

Staff Training. Scientific Organization of Work at the Factory (Contribution au problème de l'organisation scientifique du travail dans les ateliers), Gaston Vidal. Arts et Métiers, vol. 75, no. 20, May 1922, pp. 129-141, 12 figs. Activities of National Schools of Arts and Trades in training office workers.

OPTICAL INSTRUMENTS

Screw and Gear Inspection. Inspecting by Optical Projection. Machy. (N. Y.), vol. 28, no. 12, Aug. 1922, pp. 984-988, 6 figs. Description of methods, with particular data on screw and gear inspection.

P

PAINTS

Physical Properties. Some Physical Properties of Paints, P. H. Walker and J. G. Thompson. Ry. Rev., vol. 71, no. 3, July 15, 1922, pp. 76-81, 2 figs. Investigations by U. S. Bur. Standards presented at convention of Am. Soc. for Testing Matls.

Sulphate Pulp, Lined Digesters. Sulphate Pulp Made in Lined Digesters, P. C. Austin. Paper, vol. 30, no. 16, June 21, 1922, pp. 14 and 16. Prevention of leaks, improved yield and steam economy among advantages. Paper read before joint convention of Cost Assn. of Paper Industry and Am. Pulp & Paper Mill Superintendent's Assn.

PAPER MANUFACTURE

Starch, Use of. The Use of Starch in Paper Manufacture, W. A. Nivling. Paper Mill, vol. 46, no. 26, July 8, 1922, pp. 4-6 and 8, 11 figs. Consideration of various starches and their differences in sizing operation. Paper read at Superintendents' Convention.

PARACHUTES

Calthrop. A New Calthrop Parachute Development. Flight, vol. 14, no. 28, July 13, 1922, pp. 396-397, 4 figs. Parachute equipped with series of slots near periphery with flounces which deflect air escaping through them at desired downward angle.

PEAT

Boiler Firing. Experience With Peat Firing of Steam Boilers (Erfahrungen über die Verheizung von Torf im Dampfkesselbetriebe), Ph. Stauf. Zeit. des Bayerischen Revisions-Vereins. vol. 26, no. 13, July 15, 1922, pp. 103-106, 4 figs. Composition and calorific value of peat; suitability of furnaces for peat; comparative figures as to cost.

PIPE, CAST-IRON

Analysis and Selection. Getting Best Results with Cast Iron Pipe, F. A. McInnis. Fire & Water Eng., vol. 72, no. 5, Aug. 2, 1922, pp. 221-222. Practical suggestion as to selection of pipe including analyses as to sulphur content made in Boston and elsewhere

PIPE LINES

Design. Pipe Lines (Rohrleitungen), M. Fränkl. Maschinenbau, vol. 1, no. 6, June 24, 1922, pp. 343-346, 5 figs. Essential points in pipe-line installations; most economic kind of pipe; most suitable design of a given installation.

PIPE, WOOD

Notes on. Some Observations Concerning Wood Pipe, J. W Ledoux. Am. Water Works Assn. Jl., vol. 9, no. 4, July 1922, pp. 549-569. Cost design in particular; formula for strength; water hammer discharging capacity; comparison of wooden and cast-iron pipes.

PISTON RINGS

Manufacture. Development of Piston Rings (Das Wesen und die Ausbildung der Kolbenringe mit Rücksicht auf wirtschaftliche Fertigung und auf Dichtigkeit gegen Druck), Otto Graf. Maschinenbau, vol. 1, no. 6, June 24, 1922, pp. 339-343, 11 figs Old and new ways of production; deformation by hammering; testing of materials; dimensions of rings for ordinary and light-metal pistons, standardization

POWER PLANTS

Austria. The Partenstein Power Plant (Das Kraftwerk Partenstein), Adolf Kvetensky. Elektrotechnik u. Maschinenbau, vol. 40, nos. 20 and 21, May 14 and 21, 1922, pp. 229-236 and 242-246, 13 figs., May 14: Describes construction of plant and its equipment and makes calculations as to its profitability. May 21: Describes machinery equipment including Francis spiral turbines, three-phase generators, transformers, switchboard arrangements, erection of poles for overhead lines.

Birmingham, Nechells Station. Electricity Supply in Birmingham. Electrician, vol. 88, no. 2301, June 23, 1922, pp. 744-750, 7 figs. Details of 105,000-kw. ultimate capacity station started before war and now reaching completion.

Development. Notes from Report of Prime Movers Committee of N.E.L.A. Power Plant Eng., vol. 26, no. 14, July 15, 1922, pp. 697-703, 9 figs. Résumé of development in power-plant engineering during past year.

Prairie du Sac, Wis. Increased Capacity at Prairie du Sac. Power Plant Eng., vol. 26, no. 14, July 15, 1922, pp. 687-693, 15 figs. Addition of four 60-cycle, 23000-v., generators which increase output by 12,000 kva. and auxiliary changes in connection therewith.

Steam Conditions. The Choice of Steam Conditions in Modern Power Stations, L. C. Kemp. Electrician, vol. 88, no. 2302, June 30, 1922, pp. 774-777, 4 figs. Investigation indicating that more careful selection of steam conditions should be encouraged.

POWER TRANSMISSION

Radiotelegraphic. The Problem of Radiotelegraphic Power Transmission (Étude sur le problème de la télémécanique par T. S. F.), Maurice Guéritot. Onde Electrique, vol. 1, no. 3, Mar. 1922, pp. 141-151, 3 figs. Reviews work done in transmitting power by radio to perform certain work at a distance,

especially French investigations during war, and discusses difficulties of control at a distance.

PRODUCER GAS

Analysis and Composition. Producer Gas (Der Generatorgaskörper), E. Kraemer. Feuerungstechnik, vol. 10, nos. 17, 18 and 19, June 1, 15 and July 1, 1922, pp. 185–188, 199–203, and 211–214, 16 figs. June 1: Analysis and composition; gives table of limit values for CO_2, CO, H_2, and CH_4. June 15: Calculations and curves of planes of equal quantities of air, equal quantities of steam, equal temperatures, and equal efficiency. July 1: Discusses neutral plane dividing gas into two parts, one containing exothermic processes and other endothermic processes. Greatest methane content.

PULVERIZED COAL

Boiler Firing. Pulverized Coal Firing (Die Staubverbrennung), A. B. Helbig. Feuerungstechnik, vol. 10, no. 19, July 1, 1922, pp. 209–211, 2 figs. Describes various systems of feeding pulverized coal to combustion chamber.

Explosion Hazard. Pulverized Coal Is Dangerous on the Surface as Well as Underground; Precautions to be Taken in Handling It, L. D. Tracy. Coal Age, vol. 22, no. 5, Aug. 3, 1922, pp. 164–168, 5 figs. Precautions to prevent explosion, particularly with reference to driers and electrical devices; data on self-ignition. From paper read before Fire Chiefs' Club of Ohio.

Feeding. Principles of Feeding Pulverized Fuel, M. W. Arrowood. Combustion, vol. 7, no. 1, July 1922, pp. 31–34, 47, 6 figs. Consideration of proper method of injection to obtain best conditions at various points in furnace.

Household Furnaces. Burning of Powdered Coal in Household Furnaces, Thos. W. Atterbury. Engrs. & Eng., vol. 39, no. 6, June 1922, pp. 209–214, 1 fig. Reasons for adoption; present low efficiency of household furnaces; convenience of pulverized usage; smoke prevention; description of installation and costs.

Lead Smelter. Pulverized Coal at the Bunker Hill and Sullivan Smelter, Henry M. Payne. Eng. & Min. Jl.-Press, vol. 114, no. 4, July 22, 1922, pp. 149–151, 5 figs. Use of powdered fuel in Northwestern lead smelter proving to be more economical than oil; plant operates with minimum amount of attention; safety precautions taken.

R

RAILS

Bull-Head. Specification for Bull-Head Rails. Iron & Coal Trades Rev., vol. 105, no. 2836, July 7, 1922, p. 5. Specifications issued by British Eng. Standards Assn.

Wear. The Corrugation of Rails (Usure ondulatoire des Rails), M. E. Resal. Industrie des Tramways, Chemins de Fer et Transports Publics Automobiles, vol. 16, no. 181, Jan. 1922, pp. 10–17, 13 figs. Discusses question in connection with rolling of metal which may be responsible for the corrugation, and advises experiments to be made, especially to prove connection.

RAILWAY ELECTRIFICATION

France. Electrification in France, M. Sabouret, Elec. Ry. & Tramway Jl., vol. 46, nos. 1130 and 1136, May 12 and June 16, 1922, pp. 212–214 and 278–280, 5 figs. Report of chief engr. of Orleans Ry. Co. to Internat. Ry. Congress at Rome showing plans for 5000 miles to be electrified.

Main-Line Railroads. Electrification of Main Line Railroads, S. T. Dodd. Gen. Elec. Rev., vol. 25, no. 7, July 1922, pp. 439–440. Outstanding features of accomplished and contemplated installations.

Russia. Electrification Possibilities in Russia (Ruslands elektrificeringsmuligheter), E. Kraabel-Jörstad. Elektroteknisk Tidsskrift, vol. 35, no. 20, July 15, 1922, pp. 159–162. Plans for electrification at Moscow and Petrograd; water-power resources of Russia in Europe and Asia.

Trend of Development. The Electrification of Railways, F. Rowlinson. Beama, vol. 10, nos. 5 and 6, May and June 1922, pp. 349–357 and 437–444, 12 figs. Outstanding features of successful installation and facts to be considered in prospective ones.

RAILWAY OPERATION

Service of Supply. The Origin and Development of the Service of Supply, George G. Yeomans. Ry. Rev., vol. 70, nos. 23 and 24, vol. 71, no. 1, June 10, 17 and July 1, 1922, pp. 868–869, 923–927 and 12–15. Short history of most recent fundamental development in railway organization.

Train Control. Automatic Stopping of Trains and Repetition of Signals in the Cabs (Arrêt automatique des trains et Répétition des signaux sur les locomotives), J. Verdeyen. Annales de l'Association des Ingénieurs Sortis des Ecoles Speciales de Gand, vol. 12, no. 1, 1922, pp. 16–32. Reviews literature on subject. Reply by C. Van de Velde, pp. 33–48, 1 fig.

British Approve Automatic Train Control. Ry. Age, vol. 73, no. 4, July 22, 1922, pp. 149–153, 2 figs. Ministry of Transport Committee recommends intermittent-contact type; disapproves of speed control.

RAILWAY REPAIR SHOPS

Santa Fe Ry. Santa Fe Completes Modern Shops at Albuquerque. Ry. Age, vol. 73, no. 6, Aug. 5, 1922, pp. 237–242, 10 figs. Description of locomotive repair building.

RAILWAY SHOPS

Canadian Pacific at Angus. How Shop Output is Increased and Costs Reduced at Angus. Ry. Rev., vol. 70, no. 23, June 10, 1922, pp. 854–865, 19 figs. Organization and equipment and expression of value of effective shop scheduling system.

Car. Equipment and Operation of a Modern Steel Car Plant, Geo. A. Richardson. Ry. Rev., vol. 70, no. 24, June 17, 1922, pp. 913–918, 8 figs. Plant of Cambria Steel Co., Johnstown, Pa., which is integral part of steel manufacturing organization; capable of building 50 all-steel cars a day.

RAILWAY SIGNALING

Electric. Electric Control of Railway Switches and Signals (La commande électrique des grands postes d'aiguilles et signaux de chemins de fer), Lucien A.-H. Pahin. Révue Générale de l'Électricité, vol. 12, no. 1, July 8, 1922, pp. 23–31, 10 figs. Interior arrangement of electric signal cabins on French railways; describes in detail construction and operation of motor applied to each individual switch.

Locomotive Cab Signals. On the Question of Locomotive Cab Signals, Faustino Villa. Int. Ry. Assn. Bul., vol. 4, no. 5–6, May-June 1922, pp. 821–862, 17 figs. Classifications and functions; mechanical, electrical and electromechanical repeating apparatus.

Sweden. Safety and Signaling Installations on the Cristiania-Gjövik Line (Sikrings- og signalanlaeg ved Roa stasjon, Kristiania-Gjövikbanen), J. Lindboe. Teknisk Ukeblad, vol. 69, no. 26, June 30, 1922, pp. 246–250, 9 figs. Describes in detail signaling arrangements, electric power, wiring and connections, switching, electric motors, etc.

RAILWAY SWITCHES

Remote Operation. Remote Operation of Switches on the New Haven. Ry. Age, vol. 73, no. 6, Aug. 5, 1922, pp. 251–252, 6 figs. Satisfactory results are reported after 40 years experience with 28 low-voltage machines.

RAILWAY TERMINALS

Operation. Terminal Stations for Passengers, L. Maccallini. Int. Ry. Assn. Bul., vol. 4, no. 5–6, May-June 1922, pp. 753–761. Best arrangements to reduce number of movements of engines and empty cars.

St. Louis. Report on Improvement of Railroad Terminals in St. Louis. Ry. Rev., vol. 71, no. 4, July 22, 1922, pp. 99–113, 7 figs. Report on team track facilities.

RAILWAY TIES

Reinforced-Concrete. Note on Some Recent Types of Reinforced Concrete Sleepers, R. Desprets. Int. Ry. Assn. Bul., vol. 4, no. 7, July 1922, pp. 959–971, 6 figs. Investigation of Calot type tried by Paris-Orleans Ry. Co. and Vagneux type tried by Paris-Lyons-Mediterranean Ry. Co. Latter is less expensive.

RAILWAY TRACK

Effect of Rolling Stock on. Action and Reaction Between Rolling Stock and Track (Considérations générales sur les actions réciproques de la voie et du matériel roulant et sur le calcul des rails), R. Desprets. Annales des Travaux Publics de Belgique, vol. 13, no. 2, Apr. 1922, pp. 233–272, 6 figs. Analyzes forces and stresses, vertical, longitudinal and lateral action, and makes calculations of rails on this basis.

REAMERS

Standardization. Standardizing Shell Reamers and Arbors, H. S. Kartsher. Machy. (N. Y.), vol. 28, no. 11, July 1922, pp. 892–895, 7 figs. Standard dimensions governing fits, and gages used for inspection.

REFRACTORIES

Fireclay. Fireclay Refractories, C. E. Bales. Nat. Engr., vol. 26, no. 7, July 1922, pp. 300–303, 3 figs. Origin and occurrence of fireclay; mining and preparation for use; relation to boiler practice. Paper read before Kentucky No. 1, N.A.S.E.

Research. Report of the Refractory Materials Research Committee. Gas Jl., vol. 158, no. 3085, June 28, 1922, pp. 840–851 and (discussion) 851–852, 4 figs. Revision of British specification. Standardization of After-Contraction Test, by D. A. Jones. Thermal Conductivity of Refractory Materials at High Temperatures, by A. T. Green.

REFRIGERATING MACHINES

Turbo-Compressor. A New Refrigerating Machine. Ice & Refrigeration, vol. 63, no. 1, July 1922, pp. 43–45, 2 figs. Novel turbo-compressor using newly discovered low-pressure refrigerating fluid demonstrated before gathering of 300 engineers at plant of Carrier Engr. Corp., Newark, N. J.; machine especially adapted for producing cold water required in cooling air for industrial purposes.

RELATIVITY

Application in Heat Industries. The New Mechanics and Their Application in Heat Industries (La Mécanique nouvelle et ses applications pratiques aux industries du feu), P. Drosne. Chaleur et Industrie, vol. 3, nos. 21, 22, 23, 24, 25 and 26, Jan., Feb., Mar., Apr., May and June, 1922, pp. 882–886, 971–975, 1070–1076, 1165–1169, 1270–1273 and 1368–1372, 6 figs. Application of theory of relativity to calculation of zones of combustion and transformation; kinetic and atomic theories; electrons and ionization; molecular isotropic law; occlusion of gases. Concludes that new mechanics give remarkably accurate picture of underground equilibrium of natural hydrocarbons.

RIVETING

Hammers for. Operations with Riveting Hammers. Machy. (Lond.), vol. 20, no. 511, July 13, 1922, pp. 453–455, 6 figs. Examples of cold-heading and rivet-setting operations performed on high-speed riveting hammers.

ROLLING MILLS

Reversing Passes. Layout and Arrangement of Reversing Passes in Rolling Mills (Unterwerke für Umkehrwalzenstrassen), H. Baclesse. Elektrotechnische Rundschau, vol. 39, no. 1, Jan. 31, 1922, pp. 1–5, 9 figs. Electric equipment and its advantageous location and arrangement.

Sheet Mills, Reconstruction. Reconstruction of Ayrton Sheet Mills, Middlesbrough. Iron & Coal Trades Rev., vol. 104, no. 2835, June 30, 1922, pp. 967–969, 8 figs. Description of installations including gas firing for all mill furnaces.

RUBBER

Lime as Accelerator. Prepared Lime in Rubber, H. L. Terry. Rubber Age, vol. 3, no. 5, July 1922, pp. 211–212. Preparation of lime for use as inorganic accelerator in rubber industry; qualities of and impurities in lime.

Manufacture. The Rubber Industry (L'Industrie du caoutchouc), F. Jacobs. Révue Industrielle, vol. 52, nos. 4, 5, 6, 7 and 8, Feb., Mar., Apr., May and June 1922, pp. 117–233, 165–166, 194–198, 220–222 and 256–262, 21 figs. Feb.: Preparation of mixtures; washing and drying of rubber; mixing and mixers; calendering; etc. Mar.: Discusses various methods and apparatus for vulcanizing rubber Apr.: Production of manufactured articles, such as belting, erasers, sponges, etc. May: Manufacture of rubber goods, such as gas tubes, tobacco pouches, rubber bands, etc. June: Manufacture of pneumatic tubes. Continuation of serial.

Microscopic Examination. The Microscope in the Rubber Industry, W. M. Ames. Rubber Age, vol. 3, no. 5, July 1922, pp. 213–214 and 217–218, 7 figs. Laboratory requirements and definite determination of structure and characteristics.

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SCAFFOLDS

Suspended. Suspended Scaffolds for Building Construction. Contractors' & Engrs.' Monthly, vol. 4, no. 6, June 1922, pp. 45–46, 2 figs. Description of "Little Wonder" suspended scaffold, which is claimed to reduce possibilities of accidents.

SCREW THREADS

Tolerances. Screw Tolerances (Gewindetoleranzen), G. Berndt. Werkstatts Technik, vol. 16, no. 12, June 15, 1922, pp. 349–356. A compilation of material from all countries on tolerances for bolts, nuts, etc.

SEMI-DIESEL ENGINES

Construction and Application. The Semi-Diesel Engine, Its Construction and Application (Les moteurs semi-Diesel, état actual de leur construction et de leur utilisation), Adrien Schubert. Bul. de la Société d'Encouragement pour l'Industrie Nationale, vol. 134, no. 5, May 1922, pp. 418–505, 78 figs. Indicator diagrams; efficiency; fuel injection; water injection; ignition; starting; fuels, including vegetable oils; present types. Bibliography.

SEMI-STEEL

Properties and Use. Semi-Steel, J. Cameron. Metal Industry (Lond.), vol. 30, no. 26, June 30, 1922, pp. 623–629, 6 figs. Definition, field for use, tests and raw materials for production, heat treatment. Paper read before Instn. British Foundrymen. See also Foundry Trade Jl., vol. 25, no. 306, June 29, 1922, pp. 495–500, 6 figs.

SHELLAC

Origin, Utilization and Examination. Shellac Its Origin, Utilization and Examination (Der Schellack, seine Entstehung, Verarbeitung und Untersuchung), Hans Wolff. Chemiker-Zeitung, vol. 46, nos. 35 and 38, Mar. 23 and 30, 1922, pp. 265–266 and 291–293 2 figs. Mar. 23: Production; types on market; bleaching and solubility. Mar. 30: Chemical composition; properties; uses.

SMOKE ABATEMENT

Paris. The Smoke Question in Industrial Centers (La question des fumées dans les agglomérations industrielles). Journal des Usines a Gaz, vol. 46, n. 11, June 5, 1922, pp. 161–167, 2 figs. Gives text of Paris police regulations to prevent smoke, and progress in their application.

SOLDERS

Aluminum. Tests of Aluminum Solders. Automotive Industries, vol. 47, no. 4, July 27, 1922, p. 168. Data on tests on soldered joints made at McCook Field.

Metallurgical Investigation. A Metallurgical Investigation of Solders, Wallace Dent Williams. Raw Material, vol. 5, no. 6, July 1922, pp. 216–223, 6 figs. Fusibility; scratch hardness; low melting point for white metals; silver solders; autogeneous soldering; borax substitutes.

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Helical. A Coiling and Heat Treating Plant for Helical Springs, William J. Merten. Am. Soc. for Steel Treating Trans., vol. 2, no. 11, Aug. 1922, pp. 977–983, 5 figs. Main features of plant for insuring maximum economy of labor and materials consistent with securing high-grade product.

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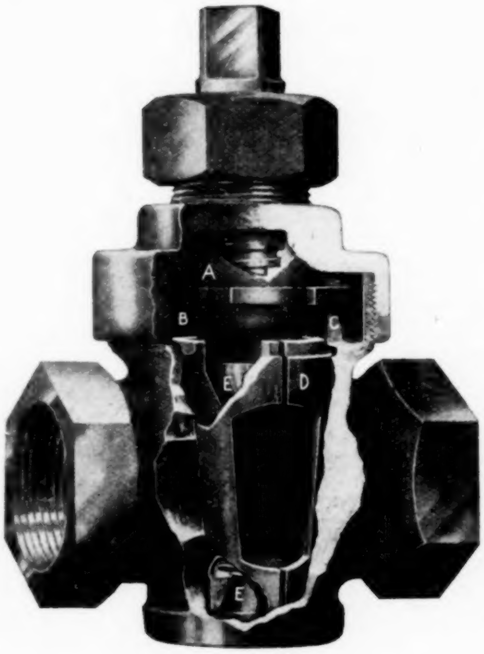

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Leaf. Leaf Springs (Ressorts a Lames superposées), C. Reynal. Arts et Métiers, vol. 75, no. 21, June 1922, pp. 164–173, 9 figs. Symmetrical and unsymmetrical springs; length, thickness and flexibility of leaves, and their calculation; sensitiveness of springs.

Manufacture. Single-Stroke Eye-Rolling Machine for Automobile Springs. Machy. (Lond.), vol. 20, no. 513, July 27, 1922, pp. 522–523, 5 figs. Description of machinery built in England.

STEAM ACCUMULATORS

Ruths. Steam Accumulators (Dampfspeicher), Johannes Ruths. Zeit. des Vereines deutscher Ingenieure, vol. 66, nos. 21, 22 and 24, May 27, June 3 and 17, 1922, pp. 509–513, 537–542 and 597–605, 62 figs. May 27: Construction and application of Ruths accumulator; possibility of equalizing pressures with various boiler types; plants already built; use of these accumulators in new constructions or extensions of present plants. June 3: Cooling losses; water-level indicators; superheat accumulators. June 17: Existing installations of steam accumulators for equalizing variations in steam for boiling and heating, and for equalizing power and steam variations.

The First Ruths Steam Accumulator in Germany (Der erste Ruths-Dampfspeicher in Deutschland), Theodor Stein. Stahl u. Eisen, vol. 42, no. 24, June 15, 1922, pp. 924–933, 9 figs. Describes steam-accumulator installation in power plant of Lauchhammer Iron Works, fluctuations in load, construction details, and particulars of cost.

STEAM ENGINES

Automatic Control. Steam Engines With Automatically Controlled Steam Supply (Dampmaskiner med automatisk regulerbar dampudtagning), H. H. Mansa. Ingeniören, vol. 31, no. 30–31, May 27, 1922, pp. 189–194, 11 figs. Steam consumption and steam economics at factories using large amount of steam.

Flywheel, Degree of Irregularity. Graphical Determination of the Degree of Irregularity of an Engine (Calcul graphique du degré d'irrégularité d'une machine), G. Laville. Révue Générale de l'Électricité, vol. 12, no. 3, July 22, 1922, pp. 85–91, 10 figs. Method for determining moment of inertia of flywheel of machines as function of degree of irregularity.

Schmidt 60-Atmos. The Schmidt 60-Atmos. Steam Engine and the Use of High-Pressure Steam in Lignite Mines (Die Schmidtsche 60-Atmosphären-Dampfmaschine und die Anwendung höchstgespannten Dampfes auf Braunkohlenbergwerken), Otto H. Hartmann and Kurt Manning. Braunkohle, vol. 20, nos. 49, 50 and 51, Mar. 11, 18 and 25, 1922, pp. 769–776, 790–795 and 805–811, 30 figs. Mar. 11: Describes vertical tube boiler developed by Schmidt's High-Temperature Steam Co., in Kassel, and gives results of experiments with maximum pressure boilers. Mar. 18: Consumption of heat of maximum-pressure reciprocating engines and turbines. Mar. 25: Advantages of maximum-pressure engines in plants utilizing waste steam.

STEAM METERS

Chemical Measurement. Measuring Steam by Chemical Means (Het meten van stoom langs chemischen weg), J. Rutten. Chemisch Weekblad, vol. 19, no. 21, May 27, 1922, pp. 229–232, 1 fig. Chemical method for measuring steam at factories where steam is largely used in various departments, which gives much more exact results than ordinary metering systems.

STEAM TURBINES

Construction. Flow of Steam and Construction of Large Steam Turbines (Strömungsvorgänge und Aufbau grosser Dampfturbinen), G. Zerkowitz. Zeit. des Vereines deutscher Ingenieure, vol. 66, nos. 22 and 23, June 3 and 10, 1922, pp. 533–536 and 561–565, 15 figs. Expansion between blades; maximum performance of flow; incomplete expansion; influence of length of blades; means of reducing wear in parts; construction of steam turbines of large capacity.

Design. Modern Steam Turbines (Les turbines à vapeur modernes), Alb. Schlag. Révue Universelle des Mines, vol. 13, nos. 2, 3, 4 and 5, Apr. 15, May 1, 15 and June 1, 1922, pp. 95–100, 189–198, 265–272 and 351–358, 15 figs. Apr. 15: Actual state of steam-turbine industry; reaction and impulse types. May 1: Principal factors influencing construction of large turbines; security of operation; efficiency; dimensions; weight and cost; etc. May 15: Power and steam consumption. June 1: Maximum power of turbines at a given speed; accidents with large turbines; lubrication.

Disks, Calculation of. Contribution to the Exact Calculation of Steam Turbine Disks with Variable Thickness (Beitrag zur genauen Berechnung der Dampfturbinenscheibenräder mit veränderlicher Dicke), Alexander Fischer. Zeit. des Oesterr. Ingenieur- u. Architekten Vereines, vol. 74, nos. 9–10 and 15–16, Mar. 3 and Apr. 14, 1922, pp. 46–49 and 71–73, 2 figs. Presents solution of the Stodola differential equation of radial displacement of rotating disks.

Hell Gate Station. Turbines at the Hell Gate Station. Power, vol. 56, no. 6, Aug. 8, 1922, pp. 194–199, 7 figs. Description of four main units which consist of two 40,000-kw. Westinghouse and two 35,000-kw. Gen. Elec. turbines.

Refrigerating Plants. Steam Turbine in the Refrigerating Plant, W. F. Schaphorst. Refrigeration, vol. 30. no. 2, Apr. 1922, pp. 27–28 and 42–44. Sixteen advantages over other types of prime movers.

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Alloy. See ALLOY STEELS.

Ball. Ball Steel, Hilton G. Freeland. Am. Soc. for Steel Treating Trans., vol. 2, no. 10, July 1922, pp. 898–911 and (discussion) 911–917, 5 figs. Ball manufacturer's problems arising from quality of steel received, and effect on final product.

Cementite Spheroidizing. Spheroidizing of Cementite in Steel, H. C. Ibsen. Forging & Heat Treating, vol. 8, no. 7, July 1922, pp. 300–303, 9 figs. Results of tests on 1 per cent carbon steel show that long-time anneal is not necessary to obtain spheroidized structure; such steel reveals increased ductility and shock-resisting value.

Chromium. See CHROMIUM STEEL.

Crystal Structure X-Ray Study. X-Ray Studies on the Crystal Structure of Steel, A. Westgren and G. Phragmen. Engineering, vol. 113, no. 2942, May 19, 1922, pp. 630–634, 12 figs. partly on supp. plate. Photograms of x-iron at 1,100 deg. cent. and 8-iron at 1,425 deg. cent.; crystal structure of iron modifications; influence of carbon or space lattice of iron in hardened steels; crystal shape of cementite. Paper read before Iron & Steel Inst.

Crystallization, Delayed. On Delayed Crystallisation in the Carbon Steels: The Formation of Pearlite, Troostite and Martensite, A. F. Hallimond. Engineering, vol. 113, no. 2946, June 16, 1922, pp. 767–769, 1 fig. Development of principles which explain delayed critical points and corresponding structure in terms of supersaturation theory. Paper read before Iron & Steel Inst.

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Rock-Drill. Breakage and Heat Treatment of Rock Drill Steel. Eng. World, vol. 21, no. 1, July 1922, pp. 39–40. Progress report to members of Advisory Board to Bur. of Mines and Bur. of Standards.

Rustless. Investigation of Rustless Steels (Några undersökningar på rostfritt stål), Bengt Kjerrman. Jernkontorets Annaler, vol. 107, no. 4, 1922, pp. 133–149, 7 figs. Development of rust- and acid-resisting steels, their thermic-microscopic examination.

Tool. See TOOL STEEL.

STEEL, HEAT TREATMENT OF

Electric-Furnace. The Electric Furnace as it Affects Over-All Cost of Heat Treated Parts, C. L. Ipsen. Am. Soc. for Steel Treating Trans., vol. 2, no. 11, Aug. 1922, pp. 984–989, 9 figs. Points out advantages and economy of electric furnaces.

High-Speed Steel. The Toughness of High Speed Steels as Affected by Their Heat Treatment, Marcus A. Grossmann. Am. Soc. for Steel Treating Trans., vol. 2, no. 11, Aug. 1922, pp. 1001–1005, 5 figs. Results of measurements on high-speed steels of 18 per cent and 13 per cent tungsten type, hardened at temperatures ranging from 1700 deg. to 2250 deg. fahr.

STEEL WORKS

Power Systems. Power Systems and the Steel Industry, E. C. Stone. Iron & Steel Elec. Engrs. Assn., vol. 4, no. 6, June 1922, pp. 279–301 and (discussion) 302–320, 4 figs. Requirements for thoroughly reliable source of power supply, and consideration.

STOKERS

Underfeed, Low-Grade Fuel. The Underfeed Stoker Successfully Burns Low-Grade Fuel. Elec. Ry. Jl., vol. 60, no. 7, Aug. 12, 1922, pp. 221–225, 9 figs. High-ash, clinkering coal burned in specially designed underfeed stokers; operation features by flexibility, high efficiency, capacities up to 350 per cent.

SUPERHEATED STEAM

Power Plants. Superheated Steam a Factor in Power Plant Economy, R. A. Holme. Eng. World, vol. 21, no. 1, July 1922, pp. 35–38, 1 fig. Capacity and efficiency of equipment increased at moderate cost by installation of superheaters; savings in connection with all types of prime movers; advanced practice at Hell Gate.

Superheating. Superheating of Steam for the Purpose of Avoiding Condensation (Die Überhitzung des Dampfes zum Zwecke der Vermeidung von Kondensationen). Wärme u. Kälte-Technik, vol. 24, no. 12, June 15, 1922, pp. 139–141. Discusses superheating in detail; makes calculation of steam velocity in pipe lines.

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TANKS

Calibration. A Rapid and Accurate Method for the Calculation of Storage Tanks, J. W. McDavid. Chem. & Met. Eng., vol. 27, no. 4, July 26, 1922, pp. 156–158, 1 fig. Description of apparatus for calibration of tanks.

TEXTILE INDUSTRY

Bleaching Without Boiling. New Process and Apparatus for Bleaching without Boiling. Color Trade Jl., vol. 11, no. 1, July 1922, p. 29, 2 figs. Method for bleaching of fine yarns and delicate fabrics by alternate use of pressure and vacuum.

Frame-Work Knitting Machinery. Frame Work Knitting Machinery, Robert Straube. Eng. Progress, vol. 3, no. 7, July 1922, pp. 141–147, 35 figs. Comparison of cloth weaving, frame-work knitting, and hand knitting; production of stitches on cotton knitting frame and formation of loops on circular frame; straight or flat frame and production of finished article on machines.

THERMIT WELDING

Process. Thermit Welding, J. H. Deppeler. Am. Welding Soc. Jl., vol. 1, no. 6, June 1922, pp. 33–36. Value of this method in all heavy operations.

TIME STUDY

Switzerland. Exact Determination of Working Time on the Basis of Time Observation (Die exakte Ermittlung von Arbeitszeiten auf Grund von Zeitbeobachtungen), A. Sonderegger. Schweizerische Bauzeitung, vol. 80, no. 1, July 1, 1922, pp. 5–8, 3 figs. Principles of time study and rate setting, especially those of Merrick; examples of calculations.

TOOL STEEL

Standardization. Tool Steel—Shall it be Standardized? Roy H. Davis. Raw Material, vol. 5, no. 6, July 1922, pp. 233–235. Arguments pro and con on substitution of analyses for tool-steel brands. Presented at Convention of Nat. Assn. of Purchasing Agents.

TOOLS

Press. Press Tool Operations in the Manufacture of Buckle Fittings, Albert Hind. Machy. (Lond.), vol. 20, no. 511, July 13, 1922, pp. 449–452, 4 figs. Details and operation of press tools for manufacture of metal brace or buckle fittings.

Straight-Form, Calculation. The Calculation of Straight-form Tools having Top Rake. Machy. (Lond.), vol. 20, no. 510, July 6, 1922, pp. 416–418, 4 figs. Method of using data given in Machinery's Handbook for figuring top rake on tools which are to cut tough and hard materials.

TRACTORS

Belt Speeds. Considerations Affecting Belt Speeds, A. B. Welty. Agricultural Eng., vol. 3, no. 7, July 1922, pp. 115–116. Data with view to determine ideal belt speed for any particular type and size of tractor.

Reactions to Hitches. Tractor and Plow Reactions to Various Hitches, O. B. Zimmerman and T. G. Sewall. Soc. Automotive Engrs. Jl., vol. 11, no. 1, July 1922, pp. 107–115 and (discussion) 115–116, 17 figs. Reactions explained with special reference to slope and cross furrows; stability analyzed.

TURBO-COMPRESSORS

High-Speed Airplane. Turbo-Compressors for High-Speed Aviation, A. Rateau. Engineering, vol. 114, nos. 2951 and 2952, July 21 and 28, 1922, pp. 91–94 and 123–125, 9 figs. Discussion of design; specific pressures and weights of air under normal atmospheric conditions. Paper read before Instn. Mech. Engrs.

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Determination. Viscosity Determination by Means of Orifices and Tubes, W. N. Bond. Physical Soc. of Lond. Proc., vol. 34, Part 4, June 15, 1922, pp. 139–144, 1 fig. Investigation of corrections applicable to determination of viscosity due to abnormal flow at ends of tubes. Expressions for end-corrections.

Determination for CO_2, N_2O, CO and N_2. Viscous Properties of CO_2, N_2O, CO and N_2, C. J. Smith. Physical Soc. of Lond. Proc., vol. 34, Part 4, June 15, 1922, pp. 155–165, 2 figs. Direct comparisons by observing time required by mercury pellet across equal volumes of gas through capillary tube. Mean area of collision deduced from Chapman's formula.

W

WATER POWER

Resources Index Inventory System. Water Resources Index Inventory Filing System. Can. Engr., vol. 42, no. 27, July 4, 1922, pp. 667–671, 3 figs. Method developed by Dominion Water Power branch for recording, collating and analyzing water resources data; coöperative investigations with provincial organizations; both graphical and written records.

WATERWAYS

St. Lawrence River. Possibilities of St. Lawrence Seaway, Wm. L. Saunders. Can. Engr., vol. 43, no. 2, July 11, 1922, pp. 128–130. Comparisons with other waterways; project economically sound; lower rates for water-borne freight power feature; would serve large population. From address before joint mtg. of A.I.E.E. and A.S.M.E.

WELDING

Pure Iron for. Manufacture and Use of Commercially Pure Iron in Gas and Electric Welding, C. A. McCune. Am. Welding Soc. Jl., vol. 1, no. 6, June 1922, pp. 8–23, 19 figs. Five characteristics of wires for successful welding.

[See also ELECTRIC WELDING; ELECTRIC WELDING, ARC; THERMIT WELDING.]